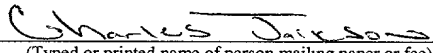
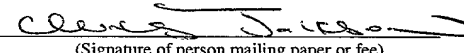


FORM PTO-1390 (REV. 11-2000)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER <b>450118-02282</b>	
<b>TRANSMITTAL LETTER TO THE UNITED STATES          DESIGNATED/ELECTED OFFICE (DO/EO/US)          CONCERNING A FILING UNDER 35 U.S.C. 371</b>				U.S. APPLICATION NO. (If known see 37 C.F.R. 1.5) <div style="font-size: 2em; font-weight: bold;">09/869897</div>	
INTERNATIONAL APPLICATION NO. <b>PCT/JP00/00013</b>		INTERNATIONAL FILING DATE <b>5 JANUARY 2000</b>		PRIORITY DATE CLAIMED <b>7 JANUARY 1999</b>	
TITLE OF INVENTION <b>ERROR RATE ESTIMATING DEVICE, RECEIVER USING ERROR RATE ESTIMATING DEVICE, ERROR RATE ESTIMATING METHOD, RECEIVING METHOD USING ERROR RATE ESTIMATING METHOD, AND INFORMATION RECORDING MEDIUM</b>					
APPLICANT(S) FOR DO/EO/US <b>Atsushi INOMATA, Tamotsu IKEDA</b>					
<p>Applicants herewith submit to the United States Designated/Elected Office (DO/EO/US) the following items and other information:</p> <ol style="list-style-type: none"> <li>1. <input checked="" type="checkbox"/> This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. 371.</li> <li>2. <input type="checkbox"/> This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. 371.</li> <li>3. <input checked="" type="checkbox"/> This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)).</li> <li>4. <input type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).</li> <li>5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2))             <ol style="list-style-type: none"> <li>a. <input type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau).</li> <li>b. <input checked="" type="checkbox"/> has been communicated by the International Bureau.</li> <li>c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US).</li> </ol> </li> <li>6. <input checked="" type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).</li> <li>7. <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))             <ol style="list-style-type: none"> <li>a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau).</li> <li>b. <input type="checkbox"/> have been communicated by the International Bureau.</li> <li>c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired.</li> <li>d. <input checked="" type="checkbox"/> have not been made and will not be made.</li> </ol> </li> <li>8. <input type="checkbox"/> A English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).</li> <li>9. <input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).</li> <li>10. <input type="checkbox"/> An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).</li> </ol> <p><b>Items 11 to 20 below concern document(s) or information included:</b></p> <ol style="list-style-type: none"> <li>11. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98.</li> <li>12. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.</li> <li>13. <input checked="" type="checkbox"/> A FIRST preliminary amendment.</li> <li>14. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment.</li> <li>15. <input type="checkbox"/> A substitute specification.</li> <li>16. <input type="checkbox"/> A change of power of attorney and/or address letter.</li> <li>17. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.</li> <li>18. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4).</li> <li>19. <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).</li> <li>20. <input checked="" type="checkbox"/> Other items or information:            PCT/RO/101 PCT/ISA/210            PCT/IB/301, 304, 308, 332            30 Sheets of Drawings, 1 Page Abstract         </li> </ol> <div style="text-align: right; margin-top: 20px;"> <p><b>EXPRESS MAIL</b></p> <p>Mailing Label Number: <b>EL742691371US</b></p> <p>Date of Deposit: <b>July 6, 2001</b></p> <p>I hereby certify that this paper or fee is being deposited with the United States Postal Service</p> <p>"Express Mail Post Office to Addressee" Service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents and Trademarks, Box PCT Washington, DC 20231.</p> <div style="margin-top: 10px;">             (Typed or printed name of person mailing paper or fee)         </div> <div style="margin-top: 10px;">             (Signature of person mailing paper or fee)         </div> </div>					

U.S. APPLICATION NO. (If known, see 37 CFR 1.50) <div style="font-size: 2em; font-weight: bold; margin-top: 5px;">09/869897</div>		INTERNATIONAL APPLICATION NO. PCT/JP00/00013		ATTORNEY'S DOCKET NO. 450118-02282	
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21. <input checked="" type="checkbox"/> The following fees are submitted				CALCULATIONS PTO USE ONLY																																																																																
<b>BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5):</b> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO .....\$1000.00  International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO .....\$860.00  International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO .....\$710.00  International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4).....\$690.00  International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4).....\$100.00																																																																																				
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<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 15%;">CLAIMS</th> <th style="width: 15%;">NUMBER FILED</th> <th style="width: 15%;">NUMBER EXTRA</th> <th style="width: 15%;">RATE</th> <th style="width: 15%;">\$</th> <th style="width: 15%;"></th> </tr> <tr> <td>Total Claims</td> <td>22 - 20 =</td> <td>2</td> <td>x \$18.00</td> <td>\$ 36.00</td> <td></td> </tr> <tr> <td>Independent Claims</td> <td>9 - 3 =</td> <td>6</td> <td>x \$80.00</td> <td>\$ 480.00</td> <td></td> </tr> <tr> <td colspan="3">MULTIPLE DEPENDENT CLAIM(S) (if applicable)</td> <td>+ \$270.00</td> <td>\$</td> <td></td> </tr> <tr> <td colspan="4" style="text-align: right;"><b>TOTAL OF ABOVE CALCULATIONS =</b></td> <td>\$</td> <td></td> </tr> <tr> <td colspan="4"> <input type="checkbox"/> Applicant claims small entity status. See 37 C.F.R. 1.27. The fees indicated          above are reduced by 1/2.       </td> <td>+</td> <td>\$</td> </tr> <tr> <td colspan="4" style="text-align: right;"><b>SUBTOTAL =</b></td> <td>\$ 1,376.00</td> <td></td> </tr> <tr> <td colspan="4">         Processing fee of <b>\$130.00</b> for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30          months from the earliest claimed priority date (37 CFR 1.492(f)).       </td> <td>\$</td> <td></td> </tr> <tr> <td colspan="4" style="text-align: right;"><b>TOTAL NATIONAL FEE =</b></td> <td>\$ 1,376.00</td> <td></td> </tr> <tr> <td colspan="4">         Fee for recording the enclosed assignments (37 CFR 1.21(h)). The assignment must be          accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). <b>\$40.00</b> per property       </td> <td>+</td> <td>\$ 0.00</td> </tr> <tr> <td colspan="4" style="text-align: right;"><b>TOTAL FEES ENCLOSED =</b></td> <td>\$ 1,376.00</td> <td></td> </tr> <tr> <td colspan="4"></td> <td style="text-align: right;">Amount to be refunded:</td> <td>\$</td> </tr> <tr> <td colspan="4"></td> <td style="text-align: right;">Charged:</td> <td>\$</td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td colspan="2" style="width: 60%; vertical-align: top;">         a. <input checked="" type="checkbox"/> One check in the amount of <b>\$ 1,376.00</b> to cover the above fees are enclosed.           b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees.          A duplicate copy of this sheet is enclosed.           c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any          overpayment to Deposit Account No. <b>50-0320</b>. A duplicate copy of this sheet is enclosed.           d. <input type="checkbox"/> Fees are to be charged to a credit card. WARNING: Information on this form may become public. <b>Credit          card information should not be included on this form.</b> Provide credit card information and authorization          on PTO-2038.       </td> <td style="width: 40%;"></td> </tr> </table> <p><b>NOTE:</b> Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.</p> <p>SEND ALL CORRESPONDENCE TO:</p> <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><b>WILLIAM S. FROMMER, ESQ.</b>  <b>FROMMER LAWRENCE &amp; HAUG LLP</b>  <b>745 FIFTH AVENUE</b>  <b>NEW YORK, NEW YORK 10151</b></p> <p>Dated: <u>July 6, 2001</u></p> </div> <div style="width: 45%; text-align: center;"> <p>_____ SIGNATURE</p> <p>_____ WILLIAM S. FROMMER NAME</p> <p>_____ 25,506 REGISTRATION NUMBER</p> </div> </div>						CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	\$		Total Claims	22 - 20 =	2	x \$18.00	\$ 36.00		Independent Claims	9 - 3 =	6	x \$80.00	\$ 480.00		MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$270.00	\$		<b>TOTAL OF ABOVE CALCULATIONS =</b>				\$		<input type="checkbox"/> Applicant claims small entity status. See 37 C.F.R. 1.27. The fees indicated above are reduced by 1/2.				+	\$	<b>SUBTOTAL =</b>				\$ 1,376.00		Processing fee of <b>\$130.00</b> for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$		<b>TOTAL NATIONAL FEE =</b>				\$ 1,376.00		Fee for recording the enclosed assignments (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). <b>\$40.00</b> per property				+	\$ 0.00	<b>TOTAL FEES ENCLOSED =</b>				\$ 1,376.00						Amount to be refunded:	\$					Charged:	\$	a. <input checked="" type="checkbox"/> One check in the amount of <b>\$ 1,376.00</b> to cover the above fees are enclosed.  b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. 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09/869897

JC18 Rec'd PCT/PTO 0 6 JUL 2001

450118-02282

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

Applicant: Inomata, et al.

Filed.: Filed Concurrently Herewith

Title of Invention: ERROR RATE ESTIMATING DEVICE, RECEIVER  
USING ERROR RATE ESTIMATING DEVICE, ERROR  
RATE ESTIMATING METHOD, RECEIVING METHOD  
USING ERROR RATE ESTIMATING METHOD, AND  
INFORMATION RECORDING MEDIUM

745 Fifth Avenue  
New York, NY 10151

**EXPRESS MAIL**

Mailing Label Number: EL742691371US

Date of Deposit: July 6, 2001

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" Service under 37 CFR 1.10 on the date indicated above and is addressed to the Honorable Commissioner of Patents and Trademarks, Washington, DC 20231.

Charles Jackson

(Typed or printed name of person mailing paper or fee)

Charles Jackson

(Signature of person mailing paper or fee)

**PRELIMINARY AMENDMENT**

Assistant Commissioner for Patents  
Box Patent Application (35 U.S.C. 111)  
Washington, D.C. 20231

Sir:

Before the issuance of the first Office Action, please amend the above-identified application as follows:

## **IN THE TITLE**

Please amend the title as follows:

ERROR RATE ESTIMATING DEVICE, RECEIVER USING ERROR RATE ESTIMATING  
DEVICE, ERROR RATE ESTIMATING METHOD, RECEIVING METHOD USING ERROR  
RATE ESTIMATING METHOD, AND INFORMATION RECORDING MEDIUM

## **IN THE SPECIFICATION**

Please delete the paragraphs beginning at page 24, line 13 through page 30, line 22.

Please replace the paragraph beginning at page 1, line 10 with the following rewritten paragraph:

The present invention relates to an error rate estimating device and a receiver using the error rate estimating device, an error rate estimating method and a receiving method using the error rate estimating method, and an information recording medium, more particularly relates to an error rate estimating device and method for determining an error rate on a channel using the number of times of normalization performed by a circuit finding a state metric, a receiver using the error rate estimating device, an error rate estimating method and a receiving method using the error rate estimating method, and an information recording medium.

Please replace the paragraph beginning at page 17, line 12 with the following rewritten paragraph:

Still another object of the present invention is to provide an information recording medium provided with software for executing a method for realizing the above error rate estimating method and decoding method.

Please replace the paragraph beginning at page 17, line 16 with the following rewritten paragraph:

According to a first aspect of the present invention, there is provided an error rate estimating device for estimating the error rate of an quadrature-modulated signal when decoding the signal, the error rate estimating device provided with a counting means for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and an estimating means for estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means.

Please replace the paragraph beginning at page 18, line 12 with the following rewritten paragraph:

According to a second aspect of the present invention, there is provided an error rate estimating method for estimating an error rate of a signal when decoding an quadrature-modulated signal, the error rate estimating method comprising (1) a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and (2) an estimating step (3) of estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step.

Please replace the paragraph beginning at page 19, line 8 with the following rewritten paragraph:

According to a third aspect of the present invention, there is provided an information recording medium for providing information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein the control information includes a count instruction for counting the number of times of normalization,



a judging step of judging a transmission system or coding rate of the signal; (2) a counting step of counting the number of times of normalization, performed when a state metric is generated, for each of the plurality of transmission systems or coding rates; (3) an estimating step of estimating the error rate for each signal each signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step; and (4) a selecting step of selecting one of a plurality of error rates for each signal estimated in the estimating step.

Please replace the paragraph beginning at page 21, line 15 with the following rewritten paragraph:

According to a sixth aspect of the present invention, there is provided an information recording medium for providing information for control executed by a receiver receiving a signal modulated by a plurality of transmission systems or coding rates sent through a channel, wherein the control information includes a judgement instruction for judging a transmission system or coding rate of the signal; a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time; an estimation instruction for estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the count step; and a selection instruction for selecting one of a plurality of error rates for each signal estimated in the estimating step.

Please replace the paragraph beginning at page 23, line 18 with the following rewritten paragraph:

According to a ninth aspect of the present invention, there is provided an information recording medium for providing information for control executed by a receiver receiving and decoding a signal modulated by a plurality of transmission systems or coding rates sent through a channel, the control information including a count instruction for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; an estimation instruction for estimating the error rate for each signal by the number of times of normalization counted in the counting step; a multiplication instruction for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and an output instruction for adding and outputting the error rate for each signal output from the multiplying step.

**IN THE CLAIMS:**

Please delete claims 23-38 from the application.

Please amend claims 1, 5, 9, 10, 11 12, 13, 16, 19, 20, and 22 as follows:

1. (Amended) An error rate estimating device for estimating the error rate of an quadrature-modulated signal when decoding the signal,
  - the error rate estimating device provided with
  - counting means for counting the number of times of normalization, performed when generating a state metric within a predetermined time and
  - an estimating means for estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively



determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means.

5. (Amended) An error rate estimating method for estimating an error rate of a signal when decoding an quadrature-modulated signal,

said error rate estimating method comprising:

a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

an estimating step of estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step.

9. (Amended) An information recording medium for providing information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein said control information includes:

a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

an estimation instruction for estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted when said count instruction is executed.

10. (Amended) An information recording medium as set forth in claim 9, wherein the estimation instruction estimates the error rate based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

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11. (Amended) An information recording medium as set forth in claim 9, wherein the estimation instruction inserts the number of times of normalization counted by the counting means into a predetermined function.
12. (Amended) An information recording medium as set forth in claim 9, wherein the count instruction counts only the number of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate.
13. (Amended) An error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, said error rate estimating device provided with:
- a judging means for judging a transmission system or coding rate of the signal;
  - a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;
  - an estimating means for estimating the error rate for each signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means; and
  - a selecting means for selecting one of a plurality of error rates for each signal estimated by the estimating means.
16. (Amended) An error rate estimating method for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, said error rate estimating method comprising:
- a judging step of judging a transmission system or coding rate of the signal;

a counting step of counting the number of times of normalization, performed when a state metric is generated, for each of the plurality of transmission systems or coding rates;

an estimating step of estimating the error rate for each signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step; and

a selecting step of selecting one of a plurality of error rates for each signal estimated in the estimating step.

19. (Amended) An information recording medium for providing information for control executed by a receiver receiving a signal modulated by a plurality of transmission systems or coding rates sent through a channel, wherein said control information includes:

a judgement instruction for judging a transmission system or coding rate of the signal;

a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time;

an estimation instruction for estimating the error rate of the from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in said count step; and

a selection instruction for selecting one of a plurality of error rates for each signal estimated in the estimating step.

said error rate estimating device comprising:

a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;

an estimating means for estimating the error rate for each signal by the number of times of normalization counted by the counting means;

a multiplying means for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating means for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

an outputting means for adding and outputting the error rate for each signal output from the multiplying means.

22. (Amended) An information recording medium for providing information for control executed by a receiver receiving and decoding a signal modulated by a plurality of transmission systems or coding rates sent through a channel,

said control information including:

a count instruction for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;

an estimation instruction for estimating the error rate for each signal by the number of times of normalization counted in the counting step;

a multiplication instruction for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step

for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

an output instruction for adding and outputting the error rate for each signal output from the multiplying step.


### **REMARKS**

The specification has been amended, claims 23-38 have been cancelled, and claims 1, 5, 9, 10, 11, 12, 13, 16, 19, 20, and 22 have been amended. All of these amendments reflect the amendments to the International Application made under PCT Article 34. The filing fee has been calculated based upon these new claims. The attached is captioned **“Version with markings to show changes made”** and indicate the changes that have been made herein.

Respectfully submitted,

FROMMER LAWRENCE & HAUG LLP  
Attorneys for Applicant

By:

  
William S. Frommer  
Reg. No. 25,606  
Tel. (212) 588-0800

**VERSION WITH MARKINGS TO SHOW CHANGES MADE**

**In the title:**

ERROR RATE ESTIMATING DEVICE, RECEIVER USING ERROR RATE ESTIMATING  
DEVICE, ERROR RATE ESTIMATING METHOD, RECEIVING METHOD USING ERROR  
RATE ESTIMATING METHOD, AND INFORMATION [PROVIDING] RECORDING  
MEDIUM

**In the specification:**

Paragraph beginning at page 1, line 10 has been amended as follows:

The present invention relates to an error rate estimating device and a receiver using the  
error rate estimating device, an error rate estimating method and a receiving method using the  
error rate estimating method, and an information [providing] recording medium, more  
particularly relates to an error rate estimating device and method for determining an error rate on  
a channel using the number of times of normalization performed by a circuit finding a state  
metric, a receiver using the error rate estimating device, an error rate estimating method and a  
receiving method using the error rate estimating method, and an information [providing]  
recording medium.

Paragraph beginning at page 17, line 12 has been amended as follows:

Still another object of the present invention is to provide an information [providing]  
recording medium provided with software for executing a method for realizing the above error  
rate estimating method and decoding method.

Paragraph beginning at page 17, line 16 has been amended as follows:

According to a first aspect of the present invention, there is provided an error rate  
estimating device for estimating the error rate of an quadrature-modulated signal when decoding

the signal, the error rate estimating device provided with a counting means for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and an estimating means for estimating the error rate of [the signal by the number of times of normalization] the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means.

Paragraph beginning at page 18, line 12 has been amended as follows:

According to a second aspect of the present invention, there is provided an error rate estimating method for estimating an error rate of a signal when decoding an quadrature-modulated signal, the error rate estimating method comprising (1) a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and (2) an estimating step (3) of estimating the error rate of [the signal by the number of times of normalization] the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step.

Paragraph beginning at page 19, line 8 has been amended as follows:

According to a third aspect of the present invention, there is provided an information [providing] recording medium for providing information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein the control information includes a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and an

estimation instruction for estimating the error rate of [the signal by the number of times of normalization] the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted when the count instruction is executed.

Paragraph beginning at page 19, line 20 has been amended as follows:

According to a fourth aspect of the present invention, there is provided an error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate estimating device provided with a judging means for judging a transmission system or coding rate of the signal; a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; an estimating means for estimating the error rate for each signal [by the number of times of normalization] from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means; and a selecting means for selecting one of a plurality of error rates for each signal estimated by the estimating means.

Paragraph beginning at page 20, line 17 has been amended as follows:

According to a fifth aspect of the present invention, there is provided an error rate estimating method for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate estimating method comprising (1) a judging step of judging a transmission system or coding rate of the signal; (2) a counting step of counting the number of times of normalization, performed when a state metric is generated, for



each of the plurality of transmission systems or coding rates; (3) an estimating step of estimating the error rate for each signal [by the number of times of normalization] each signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step; and (4) a selecting step of selecting one of a plurality of error rates for each signal estimated in the estimating step.

Paragraph beginning at page 21, line 15 has been amended as follows:

According to a sixth aspect of the present invention, there is provided an information [providing] recording medium for providing information for control executed by a receiver receiving a signal modulated by a plurality of transmission systems or coding rates sent through a channel, wherein the control information includes a judgement instruction for judging a transmission system or coding rate of the signal; a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time; an estimation instruction for estimating the error rate of the signal [by the number of times of normalization] from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission shystem or each different coding rate based on the number of times of normalization counted in the count step; and a selection instruction for selecting one of a plurality of error rates for each signal estimated in the estimating step.

Paragraph beginning at page 23, line 18 has been amended as follows:

According to a ninth aspect of the present invention, there is provided an information [providing] recording medium for providing information for control executed by a receiver receiving and decoding a signal modulated by a plurality of transmission systems or coding rates

sent through a channel, the control information including a count instruction for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; an estimation instruction for estimating the error rate for each signal by the number of times of normalization counted in the counting step; a multiplication instruction for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and an output instruction for adding and outputting the error rate for each signal output from the multiplying step.

**In the claims:**

1. (Amended) An error rate estimating device for estimating the error rate of an quadrature-modulated signal when decoding the signal,  
  
the error rate estimating device provided with  
  
counting means [(91; 101, 102, 103)] for counting the number of times of normalization, performed when generating a state metric within a predetermined time and  
  
an estimating means ']'for estimating the error rate of [the signal by the number of times of normalization] the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means.
5. (Amended) An error rate estimating method for estimating an error rate of a signal when decoding an quadrature-modulated signal,  
  
said error rate estimating method comprising:

a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

an estimating step of estimating the error rate of [the signal by the number of times of normalization] the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step.

9. (Amended) An information [providing] recording medium for providing information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein said control information includes:

a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

an estimation instruction for estimating the error rate of [the signal by the number of times of normalization] the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted when said count instruction is executed.

10. (Amended) An information [providing] recording medium as set forth in claim 9, wherein the estimation instruction estimates the error rate based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

11. (Amended) An information [providing] recording medium as set forth in claim 9, wherein the estimation instruction inserts the number of times of normalization counted by the counting means into a predetermined function.
12. (Amended) An information [providing] recording medium as set forth in claim 9, wherein the count instruction counts only the number of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate.
13. (Amended) An error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, said error rate estimating device provided with:
- a judging means [(62)] for judging a transmission system or coding rate of the signal;
  - a counting means [(91)] for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;
  - an estimating means [(92, 111)] for estimating the error rate for each signal [by the number of times of normalization] from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means; and
  - a selecting means [(32, 33)] for selecting one of a plurality of error rates for each signal estimated by the estimating means.

16. (Amended) An error rate estimating method for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, said error rate estimating method comprising:

a judging step of judging a transmission system or coding rate of the signal;

a counting step of counting the number of times of normalization, performed

when a state metric is generated, for each of the plurality of transmission systems or coding rates;

an estimating step of estimating the error rate for each signal [by the number of times of normalization] from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step; and

a selecting step of selecting one of a plurality of error rates for each signal estimated in the estimating step.

19. (Amended) An information [providing] recording medium for providing information for control executed by a receiver receiving a signal modulated by a plurality of transmission systems or coding rates sent through a channel, wherein said control information includes:

a judgement instruction for judging a transmission system or coding rate of the signal;

a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time;

an estimation instruction for estimating the error rate of the signal [by the number of times of normalization] from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or

each different coding rate based on the number of times of normalization counted in said count  
step; and

a selection instruction for selecting one of a plurality of error rates for each signal  
estimated in the estimating step.

20. (Amended) An error rate estimating device for estimating an error rate of a signal  
when decoding a signal modulated by a plurality of transmission systems or coding rates,

said error rate estimating device comprising:

a counting means [(91)] for counting the number of times of normalization,  
performed when generating a state metric, for each of the plurality of transmission systems or  
coding rates;

an estimating means [(92)] for estimating the error rate for each signal by the  
number of times of normalization counted by the counting means;

a multiplying means [(111)] for determining a value for multiplication with the  
error rate for each signal according to a value of the error rate estimated by the estimating means  
for a predetermined transmission system or coding rate among the transmission systems or  
coding rates and multiplying with that value; and

an outputting means [(32, 33)] for adding and outputting the error rate for each  
signal output from the multiplying means.

22. (Amended) An information [providing] recording medium for providing information  
for control executed by a receiver receiving and decoding a signal modulated by a plurality of  
transmission systems or coding rates sent through a channel,

said control information including:

a count instruction for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;

an estimation instruction for estimating the error rate for each signal by the number of times of normalization counted in the counting step;

a multiplication instruction for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

an output instruction for adding and outputting the error rate for each signal output from the multiplying step.

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# DESCRIPTION

ERROR RATE ESTIMATING DEVICE, RECEIVER USING ERROR RATE

5 ESTIMATING DEVICE, ERROR RATE ESTIMATING METHOD,

RECEIVING METHOD USING ERROR RATE ESTIMATING METHOD, AND

INFORMATION PROVIDING MEDIUM

## TECHNICAL FIELD

10 The present invention relates to an error rate  
estimating device and a receiver using the error rate  
estimating device, an error rate estimating method and a  
receiving method using the error rate estimating method,  
and an information providing medium, more particularly  
15 relates to an error rate estimating device and method for  
determining an error rate on a channel using the number  
of times of normalization performed by a circuit finding  
a state metric, a receiver using the error rate  
estimating device, an error rate estimating method and a  
20 receiving method using the error rate estimating method,  
and an information providing medium.

## BACKGROUND ART

At the present, in Japan, provision of a digital  
broadcasting service using a successor to the BS4  
25 scheduled to be launched as a broadcasting satellite is

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being discussed at the Radio Regulatory Council. In this digital broadcasting service, 8 SPK (Phase Shift Keying), QPSK (Quadrature PSK), and BPSK (Binary PSK) are defined as channel coding systems.

5        Figure 1 is a block diagram of an example of the configuration of a transmitter and a receiver. The transmitter 1 is comprised of a video, audio, or other information source 2, a coder 3, a puncturing unit 4, and a mapping unit 5. The information source 2 outputs data  
10    to be coded and transmitted to the coder 3. The coder 3 performs trellis coding on input 1-bit data by the coding rate  $R=1/2$  and outputs it to the puncturing unit 4 as a 2-bit coded word. The puncturing unit 4 punctures the input 2-bit data and outputs it to the mapping unit 5.  
15    The mapping unit 5 assigns the input 2-bit coded word to one signal point among four signal points shown in Fig. 5 by an quadrature modulation system and outputs an I-signal and Q-signal of the signal point to a channel 6.

      A receiver 7 is comprised of a bit insertion unit 8,  
20    a decoder 9, and decoded information 10. The bit insertion unit 8 inserts bits into the received signals (I, Q) input via the channel 6 and outputs them to the decoder 9. The decoder 9 performs trellis decoding on the input signal and outputs it as decoded information 10.  
25    The decoded information 10 shows decoded data. An image

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and sound can be obtained by reproducing the decoded information 10 with a not shown reproducing apparatus.

Information of the state metric output from the decoder 9 is supplied to a monitoring circuit 11. The monitoring circuit 11 determines an error rate on the channel 6 and outputs the information as error rate information 12. The error rate information 12, for instance, is used as data when adjusting the orientation of the antenna for receiving the data in a direction giving the lowest error rate.

Figure 2 is a block diagram showing the configuration of a coder 3. The coder 3 is a convolutional coder. An input 1-bit data  $b_0$  is coded to 2-bit data ( $c_1$ ,  $c_0$ ) and output. The output 2-bit data  $c_1$ ,  $c_0$  is generated by calculating the data  $b_0$  by a processor comprising delay circuits 21 and 22 and exclusive OR circuits 23 and 24.

That is, the data  $b_0$  is input to the delay circuit 21, the exclusive OR circuit 23, and the exclusive OR circuit 24. The data  $b_0$  input to the delay circuit 21 is delayed by one unit time and output to the delay circuit 22 and the exclusive OR circuit 23. The data input to the delay circuit 22 is further delayed for one unit time and output to the exclusive OR circuits 23 and 24. The exclusive OR circuit 23 calculates the exclusive OR of

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the three bits of data, that is, the data  $b_0$  currently input in the coder 3, the data input to the coder 3 one time unit before, and further the data input to the coder 3 two time units before, to generate the output data  $c_1$ .

5       The exclusive OR circuit 24 calculates the exclusive OR of the data  $b_0$  currently input in the coder 3 and the data input to the coder 3 two time unit before to generate an output data  $c_0$ .

10       The output data  $(c_1, c_0)$  output from the coder 3 are input to the puncturing unit 4 in this way. The puncturing unit 4 outputs the input data to the mapping unit 5 as is when outputting the data of the coding rate  $R=1/2$  to the channel 6 and punctures the input data and outputs it to the mapping unit 5 when outputting data of  
15       the coding rate  $R=3/4$  to the channel 6.

      Figures 3A and 3B are views for explaining the puncturing. As shown in Fig. 3A, the puncturing unit 4 punctures the input data  $(c_1, c_0)$  in accordance with the puncturing table shown in Fig. 3B and outputs the data  
20        $(p_1, p_0)$ .

      In the puncturing table shown in Fig. 3B, "1" shows the input data output as the data  $p_0$  or data  $p_1$  and "0" shows the input data not output (erased). For instance, the data shown in Fig. 4B is output when the data shown  
25       in Fig. 4A is input.

That is, as shown in Fig. 4A, when data  $X_1$  to  $X_6$  are input as the input data  $c_1$  and the data  $Y_1$  to  $Y_6$  are input as the input data  $c_0$  to the puncturing unit 4, since these are input in the order of the data  $c_0, c_1$ , when the data are sequentially input in the order of  $Y_1, X_1, Y_2, X_2, \dots, Y_6, X_6$  to the puncturing unit 4, as shown in Fig. 4B, the data  $X_1, Y_3, X_4$ , and  $Y_6$  are output as the output data  $p_1$  and the data  $Y_1, X_2, Y_4$ , and  $X_5$  are output as the output data  $p_0$ . Note that since the output data is output in the order of the data  $p_0, p_1$ , the data is output from the puncturing unit 4 in the order of  $Y_1, X_1, X_2, Y_3, Y_4, X_4, X_5$ , and  $Y_6$ .

The input data  $Y_1, X_1$  are output as output data  $p_0, p_1$  as is since they correspond to positions of the value 1 of the puncturing table, but the input data  $Y_2$  is deleted since it corresponds to a position of a value 0 of the puncturing table. The next output data  $X_2$  (corresponding to a position of a value 1 of the puncturing table) is output as the data  $p_0$ . Below, in the same way, data corresponding to a position of a value 0 of the puncturing table are deleted and data corresponding to a position of a value 1 of the puncturing table are output.

The data output from the puncturing unit 4 in this way are mapped onto the signal points in the quadrature

coordinate system based on the I-axis and Q-axis as shown in Fig. 5 by the mapping unit 5. The signal points are arranged at equal intervals 90 degrees apart. "p<sub>1</sub>" shown in Figs. 3A and 3B is the MSB (most significant bit) in the signal point assignment, while "p<sub>0</sub>" is the LSB (least significant bit) in the signal point assignment. That is, a signal point assignment may be expressed as (p<sub>1</sub>, p<sub>0</sub>).

The data mapped by the mapping unit 5 is input to the bit insertion unit 8 of the receiver 7 through the channel 6. Figures 6A and 6B are views explaining bit insertion. Bit insertion is processing opposite to the puncturing performed in the puncturing unit 4, that is, processing for outputting received data as is to the decoder 9 when receiving data of the coding rate  $R=1/2$  and inserting deleted data (bits) when receiving data of the coding rate  $R=3/4$ .

As shown in Fig. 6A, the bit insertion unit 8 inserts bits in the data (p'<sub>1</sub>, p'<sub>0</sub>) from the transmitter 1 through the channel 6 in accordance with the depuncturing table shown in Fig. 6B and outputs the output data (c'<sub>1</sub>, c'<sub>0</sub>). A value 1 of the depuncturing table shown in Fig. 6B indicates to output the input data as is, while the value 0 indicates to insert 0 (insert a bit).

When for example input data shown in Fig. 7A (data

output from the puncturing unit 4 and shown in Fig. 4B) is input to the bit insertion unit 8, the data shown in Fig. 7B is output. The data transmitted from the transmitter 1 is in the order of the data  $p_0, p_1$ , so the order of input into the bit insertion unit 8 of the receiver 7 also becomes the data  $p'_0, p'_1$ . Further, the order of the data output from the bit inserted unit 8 becomes the data  $c'_0, c'_1$ .

Note that the data  $p'_0, p'_1$  show the data  $p_0, p_1$  output from the transmitter having the possibility of generation of error due to the effect of noise or distortion in the channel 6.

Therefore, the data  $X_2$  input as the input data  $p'_0$  is data corresponding to a position of a value 0 of the depuncturing table, so is output as the data  $c'_0$  in a form with 0 inserted instead of the input data  $X_2$ . The data  $X_2$  is output as the data  $c'_1$ . In this way, input data positioned at a value 0 is output with 0 inserted.

Data with a bit inserted by the bit insertion unit 8 in this way is output to the decoder 9.

Figure 8 is a block diagram of the inner configuration of the decoder 9. The decoder 9 is comprised of a branch metric generator 31 (hereinafter referred to as a "BM generator 31"), an add, compare, and select (ACS) circuit 32, and a path memory 33. The signal

input to the decoder 9 is first input to the BM generator  
31 calculating the square of the Euclidean distance from  
a received signal point with the noise and distortion of  
the channel to a signal point to originally be received  
5 and generating the same as a branch metric. The branch  
metrics generated at the BM generator 31 are cumulatively  
added and compared in accordance with a convolutional  
coding trellis by the ACS circuit 32 to calculate the  
state metric of each state.

10 Figure 9 is a trellis transition diagram for  
explaining the calculation of a state metric performed by  
the ACS circuit 32. As the paths in the state 00 at the  
time  $t+1$ , two paths may be considered: the path of the  
case where the branch metric BM00 is selected at the  
15 state 00 at the time  $t$  and the path of the case where the  
branch metric BM11 is selected at a state 01 at the time  
 $t$ . The value obtained by adding the value of the branch  
metric BM00 to the state metric of the state 00 at the  
time  $t$  and the value obtained by adding the value of the  
20 branch metric BM11 to the state metric of the state 01 at  
the time  $t$  are compared and the path with the smaller  
value is used as the state metric of the state 00 at the  
time  $t+1$ .

Similarly, the state metrics of the states 01, 10,  
25 and 11 at the time  $t+1$  are calculated.

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The ACS circuit 32, as described above, controls the path memory 33 while inferring the state transition at the coding side (transmission side). If there is no noise or distortion on the channel, the input signal matches with the original transmission signal point, so the BM generator 31 generates 0 for the branch metric relating to the transmission signal point and the square of the distance between the signal points for other branch metrics. Therefore, when these branch metrics are cumulatively added in accordance with the state transition diagram and the state metric calculated in the ACS circuit 32, the state metric remains 0 for the original path, but the state metric is a large value for other paths, so the transmission signal sequence can be inferred from this.

Here, consider the case where the input signal includes noise. Since the input signal is comprised of the original transmission signal point plus noise, the branch metric relating to the original transmission signal point does not always become 0 and has indefiniteness depending on the noise power. In the same way, for other branch metrics as well, the square of the distance between signal points also has indefiniteness depending on the noise power.

However, when the noise power is small, the ACS



circuit 32 cumulatively adds the branch metrics in accordance with the state transition diagram and calculates the state metric. Since the state metric is a small value for the original path, but the state metric  
5 has a large value for other passes, it is possible to estimate the transmission signal sequence.

Figure 10 is a block diagram of the configuration of the ACS circuit 32. The ACS circuit 32 is comprised of the state 00 generating unit 41, state 01 generating unit  
10 42, state 10 generating unit 43, and state 11 generating unit 44 for finding the state metrics for the states 00, 01, 10, and 11. The state 00 generating unit 41 is comprised of adders 45-1 and 46-1 and a selector 47-1. The state metric of the state 00 and branch metric BM00  
15 at the time  $t$  are input to the adder 45-1 and added. In the same way, the state metric of the state 01 and branch metric BM11 at the time  $t$  are input to the adder 46-1 and added.

The selector 47-1 compares the values input from the  
20 adder 45-1 and the adder 46-1 and outputs the smaller value to a register 48-1. The register 48-1 stores the value of the state metric of the state 00 at the time  $t+1$ , output from the selector 47-1, as a value at the time when finding the state metric of the state 00 at the  
25 next time  $t+2$ , and outputs it to the path memory 33.

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The state 01 generating unit 42 is comprised of the adders 45-2 and 46-2 and the selector 47-2. The state metric of the state 10 and branch metric BM10 at the time t are input to the adder 45-2 and added. The state metric of the state 11 and the branch metric BM01 at the time t are input to the adder 46-2 and added. The selector 47-2 compares the values input from the adder 45-2 and the adder 46-2 and outputs the smaller value to a register 48-2. The register 48-2 stores the value of the state metric of the state 01 at the time t+1, output from the selector 47-2, as a value at the time when finding the state metric of the state 01 at the next time t+2, and outputs it to the path memory 33.

The state 10 generating unit 43 is comprised of the adders 45-3 and 46-3 and the selector 47-3. The state metric of the state 00 and the branch metric BM11 at the time t are input to the adder 45-3 and added. The state metric of the state 01 and the branch metric BM00 at the time t are input to the adder 46-3 and added. The selector 47-3 compares the values input from the adder 45-3 and the adder 46-3 and outputs the smaller value to a register 48-3. The register 48-3 stores the value of the state metric of the state 10 at the time t+1, output from the selector 47-3, as a value at the time when finding the state metric of the state 10 at the next time

t+2, and outputs it to the path memory 33.

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The state 11 generating unit 44 is comprised of the  
adders 45-3 and 46-3 and the selector 47-4. The state  
metric of the state 10 and the branch metric BM01 at the  
5 time t are input to the adder 45-4 and added, while the  
state metric of the state 11 and branch metric BM10 at  
the time t are input to the adder 46-4 and added. The  
selector 47-4 compares the values input from the adder  
45-1 and the adder 46-4 and outputs the smaller value to  
10 a register 48-4. The register 48-4 stores a value of the  
state metric of the state 11 at the time t+1, output from  
the selector 47-4, as the value at the time when finding  
the state metric of the state 11 at the next time t+2,  
and outputs it to the path memory 33.

15 However, the bit length in the above ACS circuit 32  
is limited, so overflow occurs due to the addition of the  
branch metrics, therefore processing is necessary to  
prevent overflow from occurring. The processing to  
prevent overflow from occurring in this way is called  
20 "normalization". Figure 11 shows the configuration of the  
ACS circuit 32 for calculating a state metric while  
performing normalization.

In the configuration of the ACS circuit 32 shown in  
Fig. 11, the value output from the state 00 generating  
25 unit 41 is supplied to the register 48-1 through the

subtractor 51-1, the value output from the state 01  
generating unit 42 is supplied to the register 48-2  
through the subtracter 51-2, the value output from the  
state 10 generating unit 43 is supplied to the register  
5 48-3 through the subtracter 51-3, and the value output  
from the state 11 generating unit 44 is supplied to the  
register 48-4 through the subtracter 51-4. The values  
output from the registers 48-1 to 48-4 are input to the  
path memory 33 and the minimum value processor 52.

10 The minimum value processor 52 calculates the  
minimum value of the state metrics output from the  
registers 48-1 to 48-4 and outputs the value to the  
subtracters 51-1 to 51-4, the path memory 33, and the  
monitoring circuit 11. The subtracters 51-1 to 51-4  
15 subtract the value input from the minimum value processor  
52 from the values input from the state generating units  
41 to 44 respectively corresponding to the subtracters  
51-1 to 51-4. In this way, normalization is carried out.

Figure 12 is a block diagram of the configuration of  
20 the monitoring circuit 11. The monitoring circuit 11 is  
comprised of an accumulator 61 and a table 62. The  
accumulator 61 cumulatively adds the values of the  
minimum state metric for a predetermined time and outputs  
the cumulative total to the table 62. The table 62 is  
25 comprised of a ROM (read only memory) and the like and

determines the noise of the channel by using a table establishing correspondence between a value output from the accumulator 61 and noise.

Figure 13 is a block diagram of the configuration of the accumulator 61. A timer 71 generates a pulse at a predetermined cycle and supplies the pulse to a minimum SM (status metric) value accumulator 72. The minimum SM value accumulator 72 receives as input the minimum value of the state metric output from the minimum value processor 52 (Fig. 11) and the value output and fed back from the minimum SM value accumulator 72. The value output from the minimum SM value accumulator 72 and the pulse generated at the timer 71 are supplied to the register 73.

The operation of the accumulator 61 shown in Fig. 13 will be explained referring to the timing chart in Figs. 14A to 14D. The pulse generated by the timer 71 (Fig. 14A) is a reset pulse for resetting the cumulative total of the minimum SM values. The minimum SM value accumulator 72 cumulatively adds the minimum SM values input between the pulse generated at a predetermined time  $t$  and the pulse generated at the next time  $t+1$  and outputs the value to the register 73.

When the minimum SM value accumulator 72 receives as input a value such as shown in Fig. 14B as the minimum SM

value, a cumulative value shown in Fig. 14C is output.  
That is, when receiving as input a pulse from the timer  
71 at the time  $t$ , the minimum SM value accumulator 72  
resets the cumulative total to 0. It then successively  
5 cumulatively adds the minimum SM values input between  $t$   
and  $t+1$ . Further, when a pulse from the timer 71 is input  
again at the time  $t+1$ , the cumulative total is reset to  
0.

The register 73 stores the value input from the  
10 minimum SM value accumulator 72 at the time when the  
pulse is input from the timer 71 and outputs the value to  
the table 62.

Figures 15A and 15B are views of an example of a  
table stored in the table 62. When the transmission  
15 system is QPSK and the coding rate  $R$  is  $\frac{1}{2}$ , the magnitude  
of the transmission error rate (C/N) of data on the  
channel is judged in accordance with the table shown in  
Fig. 15A. When the transmission system is QPSK and the  
coding rate  $R$  is  $\frac{3}{4}$ , the magnitude of the transmission  
20 error rate of the data on the channel is judged in  
accordance with the table shown in Fig. 15B.

Judging the error rate on the channel as described  
above required the minimum value processor 52 for  
calculating the value of the minimum state metric, the  
25 minimum SM value accumulator 72 provided at the

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monitoring circuit 11 and cumulatively adding the output from the minimum value processor 52, and the register 73 for storing the cumulative total. There was the problem that these circuits (apparatuses) 52, 72, and 73 became  
5 larger in circuit size along with an increase in the number of transmission signal points (number of states) transmitted from the transmitter 1 (four states in the above example).

Further, there was the problem that the calculation  
10 time also increased along with an increase in the number of states. Furthermore, in the BS transmission system, it is being proposed to transmit using different transmission systems for time division. When a plurality of transmission systems are used, there was the problem  
15 that, with the monitoring circuit 11 shown in Fig. 12, it became difficult to judge the transmission error rate.

#### DISCLOSURE OF THE INVENTION

An object of the present invention is to provide an  
20 error rate estimating device used for a receiver which enables a shortening of the calculation time and a reduction of the circuit scale by judging the error rate on a channel using the number of times of normalization performed in a circuit for finding a state metric.

25 Another object of the present invention is to

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provide a receiver using the above error rate estimating device.

Still another object of the present invention is to provide an error rate estimating method enabling a shortening of the calculation time when judging the error rate on the channel using the number of times of normalization performed in a circuit for finding a state metric.

Still another object of the present invention is to provide a decoding method using the above possible error rate estimating method.

Still another object of the present invention is to provide an information providing medium provided with software for executing a method for realizing the above error rate estimating method and decoding method.

According to a first aspect of the present invention, there is provided an error rate estimating device for estimating the error rate of an quadrature-modulated signal when decoding the signal, the error rate estimating device provided with a counting means for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and an estimating means for estimating the error rate of the signal by the number of times of normalization counted by the counting means.



Preferably, the estimating means estimates the error rate based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

5       Alternatively, preferably the estimating means inserts the number of times of normalization counted by the counting means into a predetermined function.

10       Alternatively, the counting means counts only the number of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate.

15       According to a second aspect of the present invention, there is provided an error rate estimating method for estimating an error rate of a signal when decoding an quadrature-modulated signal, the error rate estimating method comprising (1) a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and (2) an estimating step (3) of estimating the error rate of the signal by the number of times of  
20       normalization counted in the counting step.

25       Preferably, in the estimating step, the error rate is estimated based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

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Alternatively, preferably, in the estimating step, the number of times of normalization counted in the counting step is inserted into a predetermined function.

Alternatively, in the counting step, only the number  
5 of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate is counted.

According to a third aspect of the present invention, there is provided an information providing  
10 medium for providing information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein the control information includes a count instruction for counting the number of times of normalization, performed when  
15 generating a state metric, within a predetermined time and an estimation instruction for estimating the error rate of the signal by the number of times of normalization counted when the count instruction is executed.

According to a fourth aspect of the present invention, there is provided an error rate estimating  
20 device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate  
25 estimating device provided with a judging means for

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judging a transmission system or coding rate of the  
signal; a counting means for counting the number of times  
of normalization, performed when generating a state  
metric, for each of the plurality of transmission systems  
or coding rates; an estimating means for estimating the  
error rate for each signal by the number of times of  
normalization counted by the counting means; and a  
selecting means for selecting one of a plurality of error  
rates for each signal estimated by the estimating means.

Preferably, the selecting means selects the error  
rate according to the transmission system or the coding  
rate judged by the judging means.

Alternatively, preferably the selecting means  
selects an error rate to be output by comparing a  
plurality of error rates input with a predetermined  
reference value.

According to a fifth aspect of the present  
invention, there is provided an error rate estimating  
method for estimating an error rate of a signal when  
decoding a signal modulated by a plurality of  
transmission systems or coding rates, the error rate  
estimating method comprising (1) a judging step of  
judging a transmission system or coding rate of the  
signal; (2) a counting step of counting the number of  
times of normalization, performed when a state metric is

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generated, for each of the plurality of transmission  
systems or coding rates; (3) an estimating step of  
estimating the error rate for each signal by the number  
of times of normalization counted in the counting step;  
5 and (4) a selecting step of selecting one of a plurality  
of error rates for each signal estimated in the  
estimating step.

Preferably, in the selecting step, the error rate is  
selected according to the transmission system or the  
10 coding rate judged by the judging step.

Alternatively, preferably, in the selecting step, an  
error rate to be output is selected by comparing a  
plurality of error rates input with a predetermined  
reference value.

15 According to a sixth aspect of the present  
invention, there is provided an information providing  
medium for providing information for control executed by  
a receiver receiving a signal modulated by a plurality of  
transmission systems or coding rates sent through a  
20 channel, wherein the control information includes a  
judgement instruction for judging a transmission system  
or coding rate of the signal; a count instruction for  
counting the number of times of normalization, performed  
when generating a state metric, within a predetermined  
25 time; an estimation instruction for estimating the error

rate of the signal by the number of times of normalization counted in the count step; and a selection instruction for selecting one of a plurality of error rates for each signal estimated in the estimating step.

5       According to a seventh aspect of the present invention, there is provided an error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate  
10       estimating device comprising a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; an estimating means for estimating the error rate for each signal by  
15       the number of times of normalization counted by the counting means; a multiplying means for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating means for a predetermined transmission  
20       system or coding rate among the transmission systems or coding rates and multiplying with that value; and an outputting means for adding and outputting the error rate for each signal output from the multiplying means.

      According to an eighth aspect of the present  
25       invention, there is provided an error rate estimating

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method for estimating an error rate of a signal when  
decoding a signal modulated by a plurality of  
transmission systems or coding rates, the error rate  
estimating method comprising (1) a counting step of  
5 counting the number of times of normalization, performed  
when generating a state metric, for each of the plurality  
of transmission systems or coding rates; (2) an  
estimating step of estimating the error rate for each  
signal by the number of times of normalization counted in  
10 the counting step; (3) a multiplying step of determining  
a value for multiplication with the error rate for each  
signal according to a value of the error rate estimated  
by the estimating step for a predetermined transmission  
system or coding rate among the transmission systems or  
15 coding rates and multiplying with that value; and (4) an  
outputting step of adding and outputting the error rate  
for each signal output in the multiplying step.

According to a ninth aspect of the present  
invention, there is provided an information providing  
20 medium for providing information for control executed by  
a receiver receiving and decoding a signal modulated by a  
plurality of transmission systems or coding rates sent  
through a channel, the control information including a  
count instruction for counting the number of times of  
25 normalization, performed when generating a state metric,

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for each of the plurality of transmission systems or coding rates; an estimation instruction for estimating the error rate for each signal by the number of times of normalization counted in the counting step; a

5 multiplication instruction for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding  
10 rates and multiplying with that value; and an output instruction for adding and outputting the error rate for each signal output from the multiplying step.

According to a 10th aspect of the present invention, there is provided a receiver for receiving and decoding a  
15 signal which has been convolutionally coded, punctured, and quadrature-modulated, the receiver provided with a depuncturing means for performing processing reverse to the puncturing and a decoding means for decoding the above punctured quadrature-modulated data; the decoding  
20 means having a branch metric calculating means for calculating a branch metric of the above punctured quadrature-modulated data, an adding, comparing, and selecting means having an error estimating means for estimating an error rate of a signal and adding and  
25 comparing it for the calculated branch metric and for

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selecting a path with reference to the result of  
estimation by the error estimating means, and a path  
memory for outputting a signal metric in accordance with  
the path selected by the adding, comparing, and selecting  
5 means; and the error rate estimating means is provided  
with a counting means for counting the number of times of  
normalization, performed when generating a state metric,  
within a predetermined time and an estimating means for  
estimating an error rate of the signal by the number of  
10 times of normalization counted by the counting means.

According to an 11th aspect of the present  
invention, there is provided a decoding method for  
decoding a signal which has been convolutionally coded,  
punctured, and quadrature-modulated, the decoding method  
15 provided with (1) a depuncturing step for performing  
processing reverse to the puncturing and (2) a decoding  
step for decoding the above punctured  
quadrature-modulated data; the decoding step comprising  
(a) a step of calculating a branch metric of the above  
20 punctured quadrature-modulated data, (b) a step of  
estimating an error rate of a signal and adding and  
comparing it for the calculated branch metric and for  
selecting a path with reference to the estimated error  
rate, and (c) a step of outputting a signal matrix in  
25 accordance with the selected path; and the step of

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estimating the error rate of the signal comprises (i) a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and (ii) an estimating step of estimating an error rate of the signal by the number of times of normalization counted by the counting step.

According to a 12th aspect of the present invention, there is provided a receiver for receiving and decoding a signal which has been convolutionally coded, punctured, and quadrature-modulated, the receiver provided with a depuncturing means for performing processing reverse to the puncturing and a decoding means for decoding the above punctured quadrature-modulated data; the decoding means having a branch metric calculating means for calculating a branch metric of the above punctured quadrature-modulated data, an adding, comparing, and selecting means having an error estimating means for estimating an error rate of a signal and adding and comparing it for the calculated branch metric and for selecting a path with reference to the result of estimation by the error estimating means, and a path memory means for outputting a signal matrix in accordance with the path selected by the adding, comparing, and selecting means; and the error rate estimating means is provided with a judging means for judging a transmission

system or coding rate of the signal; a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; an estimating means for estimating the error rate for each signal by the number of times of normalization counted by the counting means; and a selecting means for selecting one of a plurality of error rates for each signal estimated by the estimating means.

10       According to a 13th aspect of the present invention, there is provided a decoding method for decoding a signal which has been convolutionally coded, punctured, and quadrature-modulated, the decoding method provided with (1) a depuncturing step for performing processing reverse  
15   to the puncturing and (2) a decoding step for decoding the above punctured quadrature-modulated data; the decoding step comprising (a) a step of calculating a branch metric of the above punctured quadrature-modulated data, (b) a step of estimating an error rate of a signal  
20   and adding and comparing it for the calculated branch metric and for selecting a path with reference to the estimated error rate, and (c) a step of outputting a signal matrix in accordance with the selected path; and  
25   the error rate estimating step of estimating the error rate comprises (i) a judging step of judging a

transmission system or coding rate of the signal; (ii) a counting step of counting the number of times of normalization, performed when a state metric is generated, for each of the plurality of transmission systems or coding rates; (iii) an estimating step of estimating the error rate for each signal by the number of times of normalization counted in the counting step; and (iv) a selecting step of selecting one of a plurality of error rates for each signal estimated in the estimating step.

According to a 14th aspect of the present invention, there is provided a receiver for receiving and decoding a signal which has been convolutionally coded, punctured, and modulated by a plurality of coding systems or coding rates, the receiver provided with a depuncturing means for performing processing reverse to the puncturing and a decoding means for decoding the above punctured quadrature-modulated data; the decoding means having a branch metric calculating means for calculating a branch metric of the above punctured quadrature-modulated data, an adding, comparing, and selecting means having an error estimating means for estimating an error rate of a signal and adding and comparing it for the calculated branch metric and for selecting a path with reference to the result of estimation by the error estimating means, and a

path memory means for outputting a signal matrix in  
accordance with the path selected by the adding,  
comparing, and selecting means; and the error rate  
estimating means is provided with a counting means for  
5 counting the number of times of normalization, performed  
when generating a state metric, within a predetermined  
time, an estimating means for estimating the error rate  
of the signal by the number of times of normalization  
counted by the counting means, and a multiplying means  
10 for determining a value for multiplication with the error  
rate for each signal according to a value of the error  
rate estimated by the estimating means for a  
predetermined transmission system or coding rate among  
the transmission systems or coding rates and multiplying  
15 with that value, and an outputting means for adding and  
outputting the error rate for each signal output from the  
multiplying means.

According to a 15th aspect of the present invention,  
there is provided a decoding method for decoding a signal  
20 which has been convolutionally coded, punctured, and  
modulated by a plurality of modulation systems or coding  
rates, the decoding method provided with (1) a  
depuncturing step for performing processing reverse to  
the puncturing and (2) a decoding step for decoding the  
25 above punctured quadrature-modulated data; the decoding

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step comprising (a) a step of calculating a branch metric  
of the above punctured quadrature-modulated data, (b) a  
step of estimating an error rate of a signal and adding  
and comparing it for the calculated branch metric and for  
5 selecting a path with reference to the estimated error  
rate, and (c) a step of outputting a signal matrix in  
accordance with the selected path; and the step of  
estimating the error rate of the signal comprises (i) a  
counting step of counting the number of times of  
10 normalization, performed when generating a state metric,  
for each of a plurality of transmission systems or coding  
rates, (ii) an estimating step of estimating an error  
rate for each signal by the number of times of  
normalization counted by the counting step, (iii) a  
15 multiplying step of determining a value for  
multiplication with the error rate for each signal  
according to a value of the error rate estimated by the  
estimating step for a predetermined transmission system  
or coding rate among the transmission systems or coding  
20 rates and multiplying with that value, and (iv) an  
outputting step of adding and outputting the error rate  
for each signal output in the multiplying step.

#### BRIEF DESCRIPTION OF THE DRAWINGS

25 Figure 1 is a block diagram of the configuration of

a transmitter and a receiver.

Figure 2 is a block diagram of the configuration of the encoder of Fig. 1.

Figures 3A and 3B are views for explaining a  
5 puncturing unit of Fig. 1.

Figures 4A and 4B are views for explaining the input/output data of the puncturing unit.

Figure 5 is a view for explaining the arrangement of signal points by the mapping unit of Fig. 1.

10 Figures 6A and 6B are views for explaining a bit insertion unit of Fig. 1.

Figures 7A and 7B are views for explaining the input/output data of the bit insertion unit.

Figure 8 is a block diagram of the configuration of  
15 the decoder of Fig. 1.

Figure 9 is a trellis diagram.

Figure 10 is a block diagram of the configuration of the ACS circuit of Fig. 8.

Figure 11 is a block diagram of the configuration of  
20 an ACS circuit performing normalization.

Figure 12 is a block diagram of the configuration of the monitoring circuit of Fig. 8.

Figure 13 is a block diagram of the configuration of the accumulator of Fig. 12.

25 Figures 14A to 14D are timing charts for explaining

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an operation of the accumulator of Fig. 13.

Figures 15A and 15B are views of a table stored in the table of Fig. 12.

Figure 16 is a block diagram of the configuration of the ACS circuit of the present invention.

Figure 17 is a block diagram of the configuration of the monitoring circuit to which the present invention is applied.

Figure 18 is a block diagram of the configuration of a normalization accumulator in Fig. 17.

Figures 19A to 19D are timing charts for explaining the operation of the normalization accumulator in Fig. 18.

Figures 20A and 20B are views of a table stored in the table of Fig. 17.

Figures 21A and 21B are views of a table stored in the table of Fig. 17.

Figure 22 is a block diagram of another configuration of the monitoring circuit.

Figure 23 is a graph illustrating the function of the function processor of Fig. 22.

Figure 24 is a view for explaining a frame structure of a different coding rate.

Figure 25 is a view for explaining another configuration of the decoder.

Figure 26 is a block diagram of the configuration of the monitoring circuit of Fig. 25.

Figure 27 is a block diagram of the configuration of the normalization accumulator of Fig. 26.

5        Figures 28A to 28F are timing charts for explaining an operation of the normalization accumulator of Fig. 27.

Figure 29 is a block diagram of another example of the configuration of the monitoring circuit.

10        Figure 30 is a block diagram of still another example of the configuration of the monitoring circuit.

Figure 31 is a view of the configuration of the selector of Fig. 30.

Figure 32 is a view of the configuration of the selector of Fig. 30.

15        Figure 33 is a view of a table stored in the selector of Fig. 30.

Figure 34 is a view of a table stored in the selector of Fig. 30.

20        Figure 35 is a block diagram of the configuration of the monitoring circuit and the receiver when simultaneously receiving signals of different coding rates.

Figure 36 is a block diagram of the configuration of the monitoring circuit of Fig. 35.

25        Figure 37 is a view of a table stored in the

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selector of Fig. 36.

Figure 38 is a view explaining the hardware configuration when realizing the coding processing by software.

5        Figure 39 is a view explaining the hardware configuration when realizing the decoding processing by software.

#### BEST MODE FOR CARRYING OUT THE INVENTION

10        A transmitter and receiver to which the present invention is applied are basically configured the same as in the configuration shown in Fig. 1, therefore explanations thereof are omitted. The method of judging the error rate on the channel performed at the receiver  
15        side in the present invention differs from that explained above. First, the configuration of the ACS circuit 32 of the decoder 9 will be explained with reference to Fig.  
16.

20        Figure 16 is a block diagram of the configuration of the ACS circuit 32 for performing normalization using the data of the upper bits of the state metrics of all states to find a state metric. The most significant bit of the N number of bits of data output from the state 00  
generating unit 41 for generating the state metric of the  
25        state 00 is input to the register 48-1 through an EXOR

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5 (exclusive OR) circuit 81-1 for calculating the exclusive OR. The N-1 number of bits other than the most significant bit are input to the register 48-1 without going through the EXOR circuit 81-1. Data from the AND circuit 82 for calculating the AND is input to the EXOR circuit 81-1 as well. Data output from the register 48-1 is supplied to the path memory 33, while the most significant bit is supplied to the AND circuit 82.

10 In the same way, the most significant bit among the N number of bits of data output from the state 01 generating unit 42 is input to the register 48-2 through the EXOR circuit 81-2, while the N-1 number of bits other than the most significant bit are input to the register 48-2 without going through the EXOR circuit 81-2. Data 15 from the AND circuit 82 is input to the EXOR circuit 81-2. Data output from the register 48-2 is supplied to the path memory 33, while the most significant bit is supplied to the AND circuit 82.

20 In addition, the most significant bit of the N number of bits of data output from the state 10 generating unit 43 is input to the register 48-3 through the EXOR circuit 81-3, while the N-1 number of bits other than the most significant bit are input to the register 48-3 without going through the EXOR circuit 81-3. Data 25 from the AND circuit 82 is input to the EXOR circuit 81-3

as well. Data output from the register 48-3 is supplied to the path memory 33, while the most significant bit is supplied to the AND circuit 82.

Further, the most significant bit of the N number of bits of data output from the state 11 generating unit 44 is input to the register 48-4 through the EXOR circuit, while the N-1 number of bits other than the most significant bit is input to the register 48-4 without going through the EXOR circuit. Data output from the AND circuit 82 is input to the EXOR circuit 81-4 as well. Data output from the register 48-4 is supplied to the path memory 33, and the most significant bit is supplied to the AND circuit 82.

The AND circuit 82 outputs 1 when all of the most significant bits of data output from the registers 48-1 to 48-4 are 1 and outputs 0 at other times. When the values of the state metrics of the states gradually increase and the most significant bit of the minimum state metric becomes 1, it uses an exclusive OR operation (EXOR circuits 81-1 to 81-4) to make the most significant bits of the state metrics of all states 0 for normalization.

Figure 17 is a block diagram of the configuration of the monitoring circuit 11. The monitoring circuit 11 is comprised of a normalization accumulator 91 and a table

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92. The normalization information is input from the ACS circuit 32 to the normalization accumulator 91. The normalization information is information output to the monitoring circuit 11 each time the normalization is performed by the ACS circuit 32.

Figure 18 is a block diagram of the configuration of the normalization accumulator 91. The normalization accumulator 91 is comprised of a timer 101, a normalization cumulative counter 102, and a register 103. Normalization information output from the ACS circuit 32 is input to the normalization cumulative counter 102. A pulse generated by the timer 101 every predetermined time is input to the normalization cumulative counter 102 as well. The pulse generated by the timer 101 is output to the register 103 as well. The output from the normalization cumulative counter 102 is input to the register 103 as well.

The operation of the normalization accumulator 91 shown in Fig. 18 will be explained referring to the timing chart in Figs. 19A to 19D. As shown in Fig. 19A, a pulse is generated for every time unit by the timer 101, and the generated pulse is supplied to the normalization cumulative counter 102 and the register 103. As shown in Fig. 19B, the normalization cumulative counter 102 counts the number of times of input when the normalization

information is output from the ACS circuit 32. In the example shown in Figs. 19A to 19D, eight times of normalization information are input during one time unit.

The normalization cumulative counter 102 outputs the counter value to the register 103 and resets its value to 0 (Fig. 19D) for every pulse supplied from the timer 101. In this way, the counter value output to and stored in the register 103 is output to the table 92 when the pulse from the timer 101 is input.

Figures 20A and 20B are views of examples of tables stored by the table 92. The table shown in Figs. 20A and 20B shows the correspondence between the counter value (count) output from the register 103 of the normalization accumulator 91 and the value of the transmission error rate (BER: bit error rate) of the channel 6 estimated from the count. Figure 20A is a table in the case where the transmission system is the QPSK system and the coding rate  $R$  is  $1/2$ , while Fig. 20B is a table in the case where the transmission system is the QPSK system and the coding rate  $R$  is  $3/4$ .

For instance, in the case where the transmission system is the QPSK system and the coding rate  $R$  is  $1/2$ , when the count supplied from the register 103 is 355 or more, the value output as the error rate information 12 of the channel 6 (Fig. 1) is  $0.50 \times 10^{-3}$ . In the same

way, a value calculated based on the table from the transmission system, coding rate, and a value corresponding to the count is output as the error rate information 12.

5        Figures 21A and 21B show tables in the case where the CN ratio (carrier to noise ratio) is output as the error rate information 12. Figure 21A is a table when the transmission system is the QPSK system and the coding rate R is 1/2, while Fig. 21B is a table when the  
10       transmission system is the QPSK system and the coding rate R is 3/4. For instance, in the case where the transmission system is the QPSK system and the coding rate R is 1/2, when the count supplied from the register 103 is 355 or more, the value output as the error rate  
15       information 12 of the channel 6 is 3.00 (dB).

Figure 22 is a block diagram of another configuration of the monitoring circuit 11. The monitoring circuit 11 shown in Fig. 22 is comprised of the normalization accumulator 91 and a function processor  
20       111. The function processor 111 estimates the error rate information 12 without using the tables shown in Figs. 20A and 20B and Figs. 21A and 21B, but by using the function f calculated from these tables.

In the table shown in Fig. 20A in the case where the  
25       transmission system is the QPSK system and the coding

rate R is 1/2, BER is  $1.09 \times 10^{-3}$  when the count is from 345 to 354 (representative value of 350) and BER is  $0.80 \times 10^{-2}$  when the count is from 335 to 344 (representative value of 340). In the other words, it is learned that if  
5 the count is reduced by 10 from 350 to 340, the value of BER increases by about four times. Calculating the equation used in the function processor 111 considering this fact gives the following equation (1):

$$f(\text{input}) = 0.0005 \times 4^{((360 - \text{input})/10)} \quad (1)$$

10 In equation (1), the above "input" shows the count input from the normalization accumulator 91.

Note that in equation (1), the range of the count able to be used as input is from 335 to 354. When the count is 334 or less,  $0.2 \times 10^{-1}$  is output as the error  
15 rate information 12, while when the count is 355 or more,  $0.5 \times 10^{-3}$  is output as the error rate information 12.

This is because a difference arises between the value obtained from the function f and the value used when preparing a table (function f no longer followed).

20 In this way, in the practical range, the function f is used in the range where there is no problem, while a value based on the count is output in other ranges.

In the same way, the following equation (2) is derived as a function f corresponding to the table of  
25 Fig. 20B in the case where the transmission system is the

QPSK system and the coding rate is 3/4:

$$f(\text{input}) = 0.0033 \times 3^{((580-\text{input})/10)} \quad (2)$$

In equation (2), the range of the count able to be used as the input is 545 to 565. When the count is 544 or less,  $1.90 \times 10^{-1}$  is output as the error rate information 12, while when the count 565 or more,  $4.80 \times 10^{-3}$  is output as the error rate information 12.

The following equation (3) is derived as a function f corresponding to the table shown in Fig. 21A in the case where the transmission system is the QPSK system and the coding rate is 1/2.

$$f(\text{input}) = 0.05^{(\text{input}-300)} \quad (3)$$

In equation (3), the range of the count able to be used as the input is 335 to 355. When the count is 334 or less, 1.50 is output as the error rate information 12, while when the count is 355 or more, 3.00 is output as the error rate information 12.

The following equation (4) is derived as a function f corresponding to the table shown in Fig. 21B in the case where the transmission system is the QPSK system and the coding rate is 3/4.

$$f(\text{input}) = 0.025^{(\text{input}-500)} \quad (4)$$

In equation (4), the range of the count able to be used as the input is 544 to 565. When the count is 544 or less, 0.85 is output as the error rate information 12,



while when the count is 565 or more, 2.20 is output as the error rate information 12.

Figure 23 shows the relation between data serving as the basis when preparing a table and a graph obtained by any one equation among equations (1) to (4). As will be understood from Fig. 23, equations (1) to (4) approximate the values of the table within the dotted lines. Outside of the dotted lines, since the equations do not approximate to the values of the table, as described above, the error rate information 12 is not obtained using equations (1) to (4), but a predetermined value is output. Note that in practice, if the BER or C/N value obtained by equations (1) to (4) is sufficient, it is possible not to output the error rate information 12 outside the range obtained by equations (1) to (4).

In the above explanation, the case where the transmission system was the QPSK system and the coding rate  $R$  was either of  $1/2$  or  $3/4$  was explained, but different transmission systems or coding rates  $R$  are mixed in some cases. For example, as shown in Fig. 24, the following explanation will be given taking as an example the case where the transmission system is the QPSK system, but the coding rate  $R$  is a mixture of  $1/2$  and  $3/4$ .

Figure 25 is a block diagram of the configuration of

the decoder 9 and the monitoring circuit 11 in the case where different coding rates  $R$  are mixed together. In this configuration, the monitoring circuit 11 receives as input information relating to the coding rate  $R$  from the bit insertion unit 8 (Fig. 1). The bit insertion unit 8 judges the coding rate  $R$ , outputs a signal as is to the decoder 9 when a signal of a coding rate  $R$  of  $1/2$  is input, and inserts bits by depuncturing and then outputs the signal to the decoder 9 when a signal of a coding rate  $R$  of  $3/4$  is input. The monitoring circuit 11 receives as input information of the judged coding rate  $R$ .

Figure 26 is a block diagram of the configuration of the monitoring circuit 11 shown in Fig. 25. The normalization accumulator 91 in this configuration receives as input the normalization information from the ACS circuit 32 and the coding rate information from the bit insertion unit 8.

Figure 27 is a block diagram of the configuration of the normalization accumulator 91 shown in Fig. 26. In this configuration, the timer 101 and the normalization cumulative counter 102 receive as input the coding rate information. The normalization cumulative counter 102 also receives as input the normalization information and the pulses output from the timer 101. The register 103

receives as input the output from the normalization  
cumulative counter 102 and the pulses from the timer 101.

The operation of the normalization accumulator 91  
shown in Figs. 28A to 28F will be explained next

5 referring to the timing chart of Fig. 27. The explanation  
will be made of the case where the transmission system is  
the QPSK system, but the coding rate  $R$  is changed in the  
order of  $1/2$ ,  $3/4$ , and  $1/2$  as shown Fig. 28A and the case  
where a pulse is generated at the timer 101 as shown in  
10 Fig. 28B. The interval between the pulse generated at the  
timer 101 at a predetermined time and the pulse the next  
time is defined as one time unit.

Here, for instance, if the coding rate information  
is made 1 when the coding rate  $R$  is  $1/2$  and is made 0  
15 when the coding rate  $R$  is  $3/4$ , when the coding rate  $R$   
changes as shown in Fig. 28A, the coding rate information  
becomes as shown in Fig. 28C. Further, as shown in Fig.  
28D, when the normalization information is input a total  
of eight times in a time unit, that is, six times when  
20 the coding rate  $R$  is  $1/2$  and two times when the coding  
rate  $R$  is  $3/4$ , in the normalization cumulative counter  
102, the normalization cumulative counter 102 counts only  
the number of times of normalization at the same coding  
rate  $R$ , in the other words, only the number of times of  
25 normalization when the coding rate information is 1.

That is, in the example shown in Fig. 28E, only the number of times of normalization when the coding rate  $R$  is  $1/2$  is counted, so the value output to the table 92 from the register 103 as the number of times of

5 normalization number for one time unit becomes six.

The table 92 uses the value input in this way and the stored table to calculate and output the error rate information 12. As the tables which the table 92 stores, the table shown in Figs. 20A and 20B or the table shown  
10 in Figs. 21A and 21B may be used. Further, it is possible to find the error rate information 12 from the function  $f$ .

Figure 29 is a block diagram of another configuration of the monitoring circuit 11 for estimating  
15 the error rate information 12 when different transmission systems or coding rates  $R$  are mixed together. In this configuration, the error rate information 12 is estimated separately for the signals with the coding rate  $R$  of  $1/2$  and the signals with the coding rate  $R$  of  $3/4$ . A  
20 normalization accumulator 91-1 and a normalization accumulator 91-2 receive as input normalization information from the ACS circuit 32. The coding rate information from the bit insertion unit 8 is supplied to the normalization accumulator 91-2 and the selector 122  
25 and is also supplied to the normalization accumulator

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91-1 through a NOT circuit 121. The coding rate  
information input to the normalization accumulator 91-1  
is input through the NOT circuit 121, so information  
opposite to that of the normalization accumulator 91-2 is  
5 input.

The information output from the normalization  
accumulator 91-1 is input to the table 92-1, while the  
information output from the normalization accumulator  
91-2 is input to the table 92-2. The information output  
10 from the table 92-1 and table 92-2 is input to the  
selector 122. The selector 122 selects and outputs one of  
the information input from the tables 92-1 and 92-2 based  
on the input coding information.

The normalization accumulator 91-1 and the  
15 normalization accumulator 91-2 are configured as shown in  
Fig. 12. The normalization accumulator 91-1 counts the  
number of times of normalization input when the coding  
rate information is of the coding rate  $R$  of  $1/2$ , while  
the normalization accumulator 91-2 counts the number of  
20 times of normalization input when the coding rate  
information is of the coding rate  $R$  of  $3/4$ . As explained  
above, since the mutually opposite coding rate  
information input to the normalization accumulator 91-1  
and the normalization accumulator 91-2 are input, when  
25 one of the number of times of normalization is being

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counted, the other is not counted.

The numbers of times of normalization counted by the normalization accumulators 91-1 and 91-2 in this way are output to the corresponding tables 92-1 and 92-2. The table 92-1 stores the tables shown in Fig. 20A and Fig. 21A, while the table 92-2 stores the tables shown in Fig. 20B and Fig. 21B. The tables 92-1 and 92-2 estimate the error rate information 12 according to the tables they store and output the results to the selector 122. The selector 122 selects the input from the tables 92-1 and 92-2 corresponding to the coding rate which the input coding rate information indicates and outputs the same as the error rate information 12.

Figure 30 is a block diagram of another configuration of the monitoring circuit 11. The selector 131 of this configuration selects and outputs an input from the tables 92-1 and 92-2 without using the coding information. The configuration of the selector 131 is shown in Fig. 31. The selector 131 stores the constant C. This constant C and the input value are compared to determine the output information. That is, when the input 0 is made the input from the table 92-1 and the input 1 is made the input from the table 92-2, the input 0 is output as the error rate information 12 if input 0 is larger than the constant C, while the input 1 is output

as the error rate information 12 if the input 0 is equal to or less than the constant C.

Figure 32 is a block diagram of another configuration of the selector 131. The selector 131  
5 outputs a value giving a predetermined weight to the input value. the multiplier 141-1 receives as input information from the table 92-1, while the multiplier 141-2 receives as input the information from the table 92-2. The multipliers 141-1 and 141-2 multiply the values  
10 input to them with a predetermined value and output the results to an adder 142. The adder 142 adds and outputs the sum of the input values.

Figure 33 is a table showing weighting values to be multiplied by the multipliers 141-1 and 141-2. The table  
15 is stored in a not shown storage unit and is supplied to the multipliers 141-1 and 141-2 of the selector 131 in accordance with need. The table is a table corresponding to the table shown in Figs. 21A and 21B. The value for the weighting is determined based on the error rate  
20 information 12 of the coding rate  $R=1/2$  (information output from the table 91-1). For instance, when information from the table 92-1 input to the multiplier 141-1 is 2.5, 1.0 is supplied as the weighting value to the multiplier 141-1 and 0.0 is supplied as the weighting  
25 value to the multiplier 141-2.

Figure 34 is another table of the weighting values. The table is a table for the case of weighting based on the information of the cumulative number of times of normalization when the coding rate  $R=3/4$ . When weighting in accordance with the table, the multipliers 141-1 and 141-2 (Fig. 32) are supplied with output from the normalization accumulator 91-2. The multipliers 141-1 and 141-2 weight the values input from the tables 92-1 and 92-2 based on the input normalization information and output the results. For example, when the information of the cumulative number of times of normalization output from the normalization accumulator 91-2 is 570, the multiplier 141-1 multiplies 0.0 with the value input from the table 92-1 by 0.0, the multiplier 141-2 multiplies 1.0 with the value input from the table 92-2, and these output the results to the adder 142.

In the above explanation, the tables 92-1 and 92-2 estimated the error rate information 12 from the stored tables, but it is also possible to estimate this using the above functions. Namely, it is also possible to use a function processor using the function of equation (3) instead of the table 92-1 and use a function processor using a function of equation (2) instead of the table 92-2.

Next, a monitoring circuit 11 in the case of



simultaneously receiving and processing two or more signals transmitted by different transmission systems (coding rates) will be explained. Figure 35 is a block diagram of the configuration of a receiver including a monitoring circuit 11 which simultaneously receives and processes two or more signals transmitted by different transmission systems. The monitoring circuit 11 receives as input normalization information from the decoders 9 and 9'.

Figure 36 is a block diagram of the configuration of the monitoring circuit 11 of Fig. 35. The normalization accumulator 91-1 receives as input the normalization information of the encoder 9, while the normalization accumulator 91-2 receives as input the normalization information of the coder 9'. The information output from the normalization accumulator 91-1 is input to the table 92-1, while the information output from the normalization accumulator 91-2 is input to the table 92-2. The information output from the tables 92-1 and 92-2 are input to the selector 131.

The normalization accumulators 91-1 and 91-2 are configured is shown in Fig. 3. The normalization accumulator 91-1 cumulatively adds the number of times of normalization for a signal of a coding rate  $R$  of  $1/2$ , while the normalization accumulator 91-2 cumulatively

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adds the number of times of normalization of a signal of  
a coding rate  $R$  of  $3/4$ . The table 92-1 stores the table  
of Fig. 21A, while the table 92-2 stores the table of  
Fig. 21B. The selector 131 is configured as shown in Fig.  
5 32, stores the table shown in Fig. 37, weights the input  
value based on the stored table, and outputs the result.

The table shown in Fig. 37 shows a table in the case  
of weighting based on an estimated value of the error  
10 rate information 12 for a coding rate  $R=3/4$  (information  
output from the table 92-2). For instance, when the  
estimated value output from the table 92-2 is 2.5, the  
selector 131 multiplies 1.0 with the estimated value  
input from the table 92-1 based on the table shown in  
15 Fig. 37, multiplies 0.0 with the estimated value input  
from the table 92-2, adds the values, and outputs the  
result.

As described above, since the error rate on the  
channel is calculated based on the number of times of  
20 normalization performed in the ACS circuit 32 for finding  
the state metric, the circuit can be made smaller and  
simpler. It is also possible to properly estimate the  
error rate information for a signal transmitted by  
different transmission systems or coding rates.

25 Next, an explanation will be given, using Fig. 38,

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of the hardware configuration of the transmitter 1 in the case of coding processing explained using Fig. 1 to Fig. 37 by software.

In Fig. 38, the transmitter 1 is provided with a CPU  
5 (central processing unit) 1001 for executing a processing program, a ROM (read only memory) 1002 storing a processing program for processing in accordance with a coding routine explained using Fig. 1 to Fig. 37, a RAM (random access memory) 1003 temporarily storing  
10 processing data, an external storage 1004 storing data to be coded and transmitted, and a communications I/F (interface) 1005 for transmitting an I-signal and Q-signal of a signal point through the channel 6 to the receiver 7. Further, it is provided with a path 1006  
15 connected to the circuits for transmission of the program or data.

The external storage 1004 is a randomly accessible information storage medium such as a magnetic disk or optical disk.

20 Note that the processing program of the present embodiment is stored in the ROM 1002 in this configuration, but it is also possible to have it stored in an external storage 1004 and to transfer it through the bus 1006 to the RAM 1003 at the time of execution and  
25 execute it by the CPU 1001. Further, it is also possible

to configure the communications I/F 1005 to be able to transmit and receive a signal, have the processing program received by the communications I/F 1005 from the external storage through the channel, store it in the RAM 1003 or the external storage 1004, and execute it at the CPU 1001.

That is, the transmitter 1 may introduce the computer program for the above processing for processing at the CPU 1001 through not only a medium comprised of a magnetic disk, CD-ROM, or other information storage medium, but also the Internet, digital satellite, or other transmission medium.

An explanation will be given, using Fig. 39, of the hardware configuration of the receiver 1 in the case of decoding processing explained using Fig. 1 to Fig. 37 by software.

In Fig. 39, the receiver 7 is provided with a CPU (central processing unit) 2001 for executing a processing program, a ROM (read only memory) 2002 storing a processing program for processing in accordance with a decoding routine explained using Fig. 1 to Fig. 37, a RAM (random access memory) 2003 temporarily storing processing data, an external storage 2004 storing data to be decoded, that is, decoding information 10, and a communications I/F (interface) 2005 for receiving an I-

signal and Q-signal from the transmitter 1 through the channel 6. Further, it is provided with a path 2006 connected to the circuits for transmission of the program or data.

5           The external storage 2004 is a randomly accessible information storage medium such as a magnetic disk or optical disk.

          Note that the processing program of the present embodiment is stored in the ROM 2002 in this  
10   configuration, but it is also possible to have it stored in an external storage 2004 and to transfer it through the bus 2006 to the RAM 2003 at the time of execution and execute it by the CPU 2001. Further, it is also possible to configure the communications I/F 2005 to be able to  
15   transmit and receive a signal, have the processing program received by the communications I/F 2005 from the external storage through the channel, store it in the RAM 2003 or the external storage 2004, and execute it at the CPU 2001.

20           That is, the receiver 7 may introduce the computer program for the above processing for processing at the CPU 2001 through not only a medium comprised of a magnetic disk, CD-ROM, or other information storage medium, but also the Internet, digital satellite, or  
25   other transmission medium.

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As explained above, according to the above embodiment using the error rate estimating device, the error rate estimating method, and the medium of the present invention, since the number of times of normalization performed when generating a state metric is counted within a predetermined time and the error rate of a signal is estimated by the counted number of times of normalization, the device for estimating the error rate of the signal can be made smaller in configuration and can perform processing at a high speed.

Further, according to the above embodiment using the error rate estimating device, the error rate estimating method, and the medium of the present invention, since the number of times of normalization performed when generating a state metric is counted for each of a plurality of transmission systems or coding rates and the error rate for each signal is estimated by the counted number of times of normalization, the device for estimating the error rate of the signal can be made smaller in configuration and can perform processing at a high speed.

Further, according to the above embodiment utilizing the error rate estimating device, error rate estimating method, and medium of the present invention, since the number of times of normalization performed when

generating a state metric is counted for each of a plurality of transmission systems or coding rates, the error rate for each signal is estimated by the counted number of times of normalization, a value to be multiplied with an error rate for each signal is determined in accordance with the value of the error rate estimated by the estimating means for a predetermined transmission system or coding rate and multiplied, and the value is added and output, the device for estimating the error rate of the signal can be made smaller in configuration and can perform processing at a high speed.

#### INDUSTRIAL APPLICABILITY

The error rate estimating device and the error rate estimating method of the present invention may be applied to various apparatuses for transmitting signals.

CLAIMS

1. An error rate estimating device for estimating the error rate of an quadrature-modulated signal when decoding the signal,

5 the error rate estimating device provided with counting means ~~(91, 101, 102, 103)~~ for counting the number of times of normalization, performed when generating a state metric within a predetermined time and an estimating means (92, 111) for estimating  
10 the error rate of the signal by the number of times of normalization counted by the counting means.

2. An error rate estimating device as set forth in claim 1, wherein the estimating means estimates the error rate based on a table establishing correspondence between  
15 the number of times of normalization and the error rate on a channel.

3. An error rate estimating device as set forth in claim 1, wherein the estimating means inserts the number of times of normalization counted by the counting means  
20 into a predetermined function.

4. An error rate estimating device as set forth in claim 1, wherein the counting means counts only the number of times of normalization for a signal of a predetermined transmission system or a predetermined  
25 coding rate.



5. An error rate estimating method for estimating an error rate of a signal when decoding an quadrature-modulated signal,

said error rate estimating method comprising:

5 a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

an estimating step of estimating the error rate of the signal by the number of times of normalization counted in the counting step.

6. An error rate estimating method as set forth in claim 5, wherein in the estimating step, the error rate is estimated based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

7. An error rate estimating method as set forth in claim 5, wherein in the estimating step, the number of times of normalization counted in the counting step is inserted into a predetermined function.

8. An error rate estimating method as set forth in claim 5, wherein in the counting step, only the number of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate is counted.

9. An information providing medium for providing

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information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein said control information includes:

5                   a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

                  an estimation instruction for estimating the error rate of the signal by the number of times of  
10 normalization counted when said count instruction is executed.

10. An information providing medium as set forth in claim 9, wherein the estimation instruction estimates the error rate based on a table establishing correspondence  
15 between the number of times of normalization and the error rate on a channel.

11. An information providing medium as set forth in claim 9, wherein the estimation instruction inserts the number of times of normalization counted by the counting  
20 means into a predetermined function.

12. An information providing medium as set forth in claim 9, wherein the count instruction counts only the number of times of normalization for a signal of a predetermined transmission system or a predetermined  
25 coding rate.

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13. An error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates,

5                   said error rate estimating device provided with:

                  a judging means (62) for judging a transmission system or coding rate of the signal;

                  a counting means (91) for counting the number  
10 of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;

                  an estimating means (92, 111) for estimating the error rate for each signal by the number of times of  
15 normalization counted by the counting means; and

                  a selecting means (32, 33) for selecting one of a plurality of error rates for each signal estimated by the estimating means.

14. An error rate estimating device as set forth in  
20 claim 13, wherein said selecting means selects the error rate according to the transmission system or the coding rate judged by the judging means.

15. An error rate estimating device as set forth in claim 13, wherein the selecting means selects an error  
25 rate to be output by comparing a plurality of error rates

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input with a predetermined reference value.

16. An error rate estimating method for estimating  
an error rate of a signal when decoding a signal  
modulated by a plurality of transmission systems or  
5 coding rates, said error rate estimating method  
comprising:

a judging step of judging a transmission system  
or coding rate of the signal;

10 a counting step of counting the number of times  
of normalization, performed when a state metric is  
generated, for each of the plurality of transmission  
systems or coding rates;

an estimating step of estimating the error rate  
for each signal by the number of times of normalization  
15 counted in the counting step; and

a selecting step of selecting one of a  
plurality of error rates for each signal estimated in the  
estimating step.

17. An error rate estimating method as set forth in  
20 claim 16, further comprising, in said selecting step,  
selecting the error rate according to the transmission  
system or the coding rate judged by the judging step.

18. An error rate estimating method as set forth in  
claim 16, further comprising, in said selecting step,  
25 selecting an error rate to be output by comparing a

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plurality of error rates input with a predetermined reference value.

19. An information providing medium for providing information for control executed by a receiver receiving  
5 a signal modulated by a plurality of transmission systems or coding rates sent through a channel, wherein said control information includes:

a judgement instruction for judging a transmission system or coding rate of the signal;  
10 a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time;

an estimation instruction for estimating the error rate of the signal by the number of times of  
15 normalization counted in said count step; and

a selection instruction for selecting one of a plurality of error rates for each signal estimated in the estimating step.

20. An error rate estimating device for estimating  
20 an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates,

said error rate estimating device comprising:

a counting means (91) for counting the number  
25 of times of normalization, performed when generating a

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state metric, for each of the plurality of transmission systems or coding rates;

an estimating means (92) for estimating the error rate for each signal by the number of times of normalization counted by the counting means;

a multiplying means (111) for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating means for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

an outputting means (32, 33) for adding and outputting the error rate for each signal output from the multiplying means.

21. An error rate estimating method for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates,

said error rate estimating method comprising:

a counting step of counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;

an estimating step of estimating the error rate for each signal by the number of times of normalization

counted in the counting step;

5 a multiplying step of determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

10 an outputting step of adding and outputting the error rate for each signal output in the multiplying step.

22. An information providing medium for providing information for control executed by a receiver receiving and decoding a signal modulated by a plurality of transmission systems or coding rates sent through a  
15 channel,

said control information including:

a count instruction for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems  
20 or coding rates;

an estimation instruction for estimating the error rate for each signal by the number of times of normalization counted in the counting step;

25 a multiplication instruction for determining a value for multiplication with the error rate for each

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signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

5                   an output instruction for adding and outputting the error rate for each signal output from the multiplying step.

23. A receiver (6) for receiving and decoding a signal which has been convolutionally coded, punctured,  
10 and quadrature-modulated,

said receiver provided with:

a depuncturing means (8) for performing processing reverse to said puncturing and

a decoding means (9) for decoding the above  
15 punctured quadrature-modulated data;

said decoding means having

a branch metric calculating means (31) for calculating a branch metric of the above punctured quadrature-modulated data,

20                   an adding, comparing, and selecting means (32, 11) having an error estimating means (11) for estimating an error rate of a signal and adding and comparing it for the calculated branch metric and for selecting a path with reference to the result of estimation by the error  
25 estimating means, and

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a path memory (33) for outputting a signal matrix in accordance with the path selected by said adding, comparing, and selecting means; and

said error rate estimating means (11) is  
5 provided with:

a counting means (91) for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

an estimating means (92, 111) for estimating an  
10 error rate of said signal by the number of times of normalization counted by said counting means.

24. A receiver as set forth in claim 23, wherein the estimating means estimates the error rate based on a table establishing correspondence between the number of  
15 times of normalization and the error rate on a channel.

25. A receiver as set forth in claim 23, wherein the estimating means inserts the number of times of normalization counted by the counting means into a predetermined function.

20 26. A receiver as set forth in claim 23, wherein the counting means counts only the number of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate.

27. A decoding method for decoding a signal which  
25 has been convolutionally coded, punctured, and

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quadrature-modulated,

said decoding method provided with:

a depuncturing step for performing processing  
reverse to said puncturing and

5 a decoding step for decoding the above  
punctured quadrature-modulated data;

said decoding step comprising

a step of calculating a branch metric of the  
above punctured quadrature-modulated data,

10 a step of estimating an error rate of a signal  
and adding and comparing it for the calculated branch  
metric and for selecting a path with reference to the  
estimated error rate, and

a step of outputting a signal matrix in  
15 accordance with the selected path; and

said step of estimating the error rate of the  
signal comprises

a counting step of counting the number of times  
of normalization, performed when generating a state  
20 metric, within a predetermined time and

an estimating step of estimating an error rate  
of said signal by the number of times of normalization  
counted by said counting step.

28. A decoding method as set forth in claim 27,  
25 wherein, in the estimating step, the error rate is

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estimated based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

29. A decoding method as set forth in claim 27,  
5 wherein, in the estimating step, the number of times of normalization counted in the counting step is inserted into a predetermined function.

30. A decoding method as set forth in claim 27,  
wherein, in the counting step, only the number of times  
10 of normalization for a signal of a predetermined transmission system or a predetermined coding rate is counted.

31. A receiver (6) for receiving and decoding a  
signal which has been convolutionally coded, punctured,  
15 and quadrature-modulated,

said receiver provided with:

a depuncturing means (8) for performing  
processing reverse to said puncturing and

a decoding means (9) for decoding the above  
20 punctured quadrature-modulated data;

said decoding means (9) having

a branch metric calculating means (31) for  
calculating a branch metric of the above punctured  
quadrature-modulated data,

25 an adding, comparing, and selecting means (11,

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32) having an error estimating means (11) for estimating an error rate of a signal and adding and comparing it for the calculated branch metric and for selecting a path with reference to the result of estimation by the error  
5 estimating means, and

a path memory means (33) for outputting a signal matrix in accordance with the path selected by said adding, comparing, and selecting means; and

said error rate estimating means (11) is  
10 provided with:

a judging means (62) for judging a transmission system or coding rate of the signal;

a counting means (91) for counting the number of times of normalization, performed when generating a  
15 state metric, for each of the plurality of transmission systems or coding rates;

an estimating means (92, 111) for estimating the error rate for each signal by the number of times of normalization counted by the counting means; and

20 a selecting means for selecting one of a plurality of error rates for each signal estimated by the estimating means.

32. A receiver as set forth in claim 31, wherein said selecting means selects the error rate according to  
25 the transmission system or the coding rate judged by the

judging means.

33. A receiver as set forth in claim 31, wherein  
the selecting means selects an error rate to be output by  
comparing a plurality of error rates input with a  
5 predetermined reference value.

34. A decoding method for decoding a signal which  
has been convolutionally coded, punctured, and  
quadrature-modulated,  
said decoding method provided with:  
10 a depuncturing step for performing processing  
reverse to said puncturing and  
a decoding step for decoding the above  
punctured quadrature-modulated data;  
said decoding step comprising  
15 a step of calculating a branch metric of the  
above punctured quadrature-modulated data,  
a step of estimating an error rate of a signal  
and adding and comparing it for the calculated branch  
metric and for selecting a path with reference to the  
20 estimated error rate, and  
a step of outputting a signal matrix in  
accordance with the selected path; and  
said error rate estimating step of estimating  
the error rate comprises  
25 a judging step of judging a transmission system

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or coding rate of the signal;

a counting step of counting the number of times of normalization, performed when a state metric is generated, for each of the plurality of transmission

5 systems or coding rates;

an estimating step of estimating the error rate for each signal by the number of times of normalization counted in the counting step; and

a selecting step of selecting one of a  
10 plurality of error rates for each signal estimated in the estimating step.

35. A decoding method as set forth in claim 34, wherein, in the selecting step, an error rate in accordance with the transmission system or coding rate  
15 judged by said judging step is selected.

36. A decoding method as set forth in claim 34, wherein, in the estimating step, the error rate output is selected comparing a plurality of input error rates and a predetermined reference value.

20 37. A receiver (6) for receiving and decoding a signal which has been convolutionally coded, punctured, and modulated by a plurality of coding systems or coding rates,

said receiver provided with:

25 a depuncturing means (8) for performing

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processing reverse to said puncturing and

a decoding means (9) for decoding the above  
punctured quadrature-modulated data;

said decoding means having

5 a branch metric calculating means (31) for  
calculating a branch metric of the above punctured  
quadrature-modulated data,

an adding, comparing, and selecting means (11,  
32) having an error estimating means (11) for estimating  
10 an error rate of a signal and adding and comparing it for  
the calculated branch metric and for selecting a path  
with reference to the result of estimation by the error  
estimating means, and

a path memory means (33) for outputting a  
15 signal matrix in accordance with the path selected by  
said adding, comparing, and selecting means; and

said error rate estimating means is provided  
with:

a counting means (91) for counting the number  
20 of times of normalization, performed when generating a  
state metric, within a predetermined time,

an estimating means (92, 111) for estimating  
the error rate of the signal by the number of times of  
normalization counted by the counting means, and

25 a multiplying means (111) for determining a

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value for multiplication with the error rate for each  
signal according to a value of the error rate estimated  
by the estimating means for a predetermined transmission  
system or coding rate among the transmission systems or  
5 coding rates and multiplying with that value, and  
an outputting means for adding and outputting  
the error rate for each signal output from the  
multiplying means.

38. A decoding method for decoding a signal which  
10 has been convolutionally coded, punctured, and modulated  
by a plurality of modulation systems or coding rates,

said decoding method provided with:

a depuncturing step for performing processing  
reverse to said puncturing and

15 a decoding step for decoding the above  
punctured quadrature-modulated data;

said decoding step comprising

a step of calculating a branch metric of the  
above punctured quadrature-modulated data,

20 a step of estimating an error rate of a signal  
and adding and comparing it for the calculated branch  
metric and for selecting a path with reference to the  
estimated error rate, and

a step of outputting a signal matrix in  
25 accordance with the selected path; and

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"POST"



said step of estimating the error rate of the  
signal comprises

a counting step of counting the number of times  
of normalization, performed when generating a state  
5 metric, for each of a plurality of transmission systems  
or coding rates,

an estimating step of estimating an error rate  
for each signal by the number of times of normalization  
counted by said counting step,

10 a multiplying step of determining a value for  
multiplication with the error rate for each signal  
according to a value of the error rate estimated by the  
estimating step for a predetermined transmission system  
or coding rate among the transmission systems or coding  
15 rates and multiplying with that value, and

an outputting step of adding and outputting the  
error rate for each signal output in the multiplying  
step.

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## ABSTRACT

To reduce the size of the device for judging the error rate on a channel and reducing the amount of processing, a normalization accumulator cumulatively adds the number of times that normalization is performed within a predetermined time in an ACS circuit calculating a state metric. The table stores a table establishing correspondence between the number of times of normalization cumulatively added by the normalization accumulator. The table uses the stored table to judge and output an error rate corresponding to the input cumulative number of times of normalization.

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FIG.1

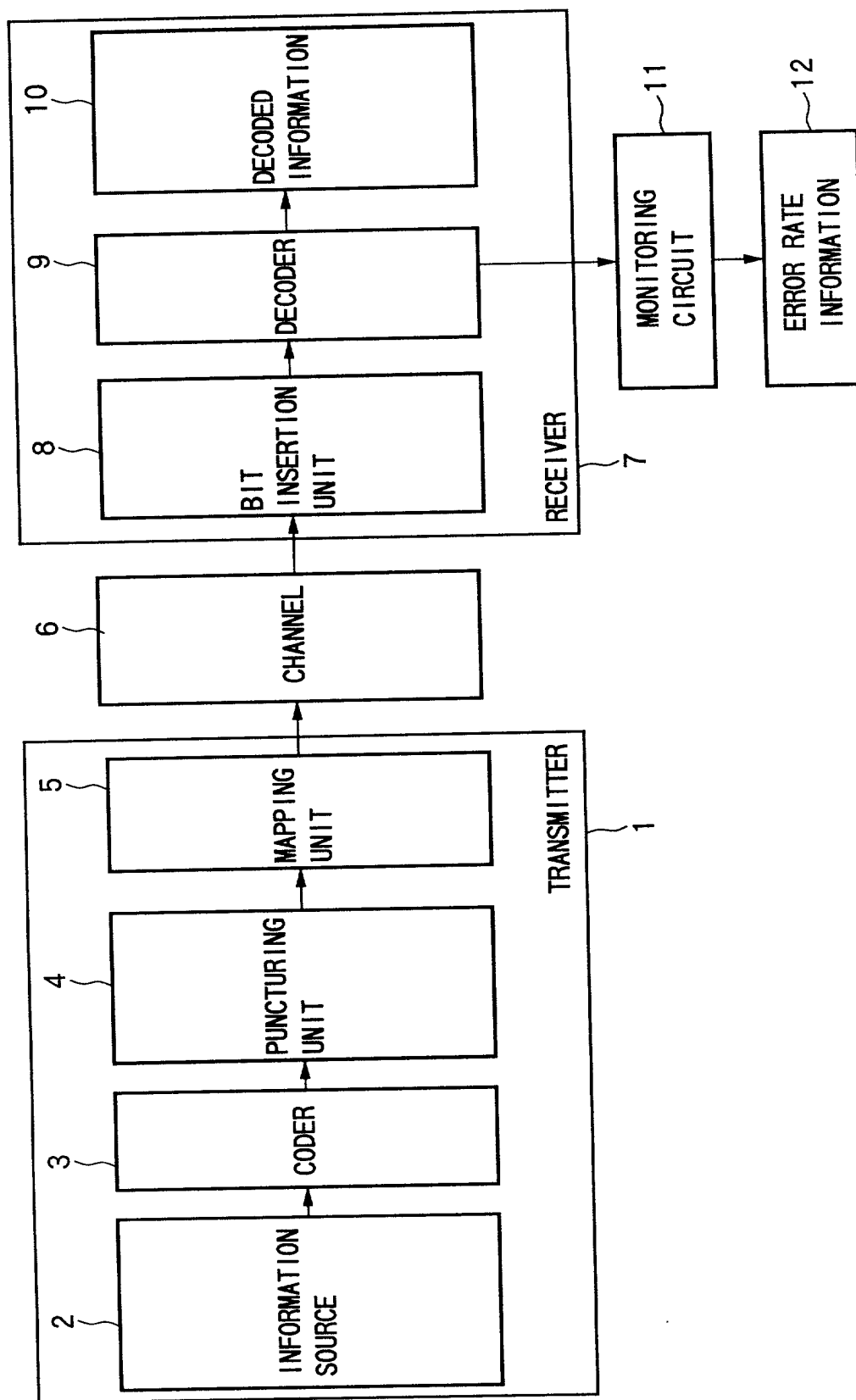


FIG.2

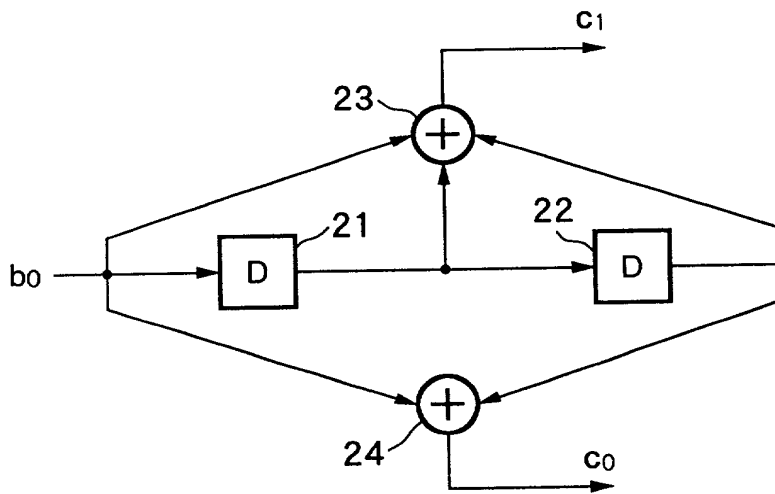
CODER 3

FIG.3A

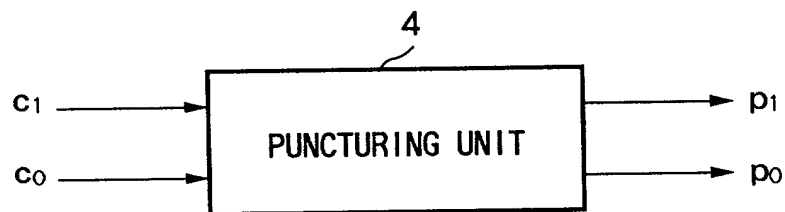


FIG.3B

$c_1$	1	1	0
$c_0$	1	0	1

FIG.4A

INPUT	c <sub>1</sub>	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	X <sub>6</sub>
	c <sub>0</sub>	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>	Y <sub>4</sub>	Y <sub>5</sub>	Y <sub>6</sub>

FIG.4B

OUTPUT	p <sub>1</sub>	X <sub>1</sub>	Y <sub>3</sub>	X <sub>4</sub>	Y <sub>6</sub>
	p <sub>0</sub>	Y <sub>1</sub>	X <sub>2</sub>	Y <sub>4</sub>	X <sub>5</sub>

FIG.5

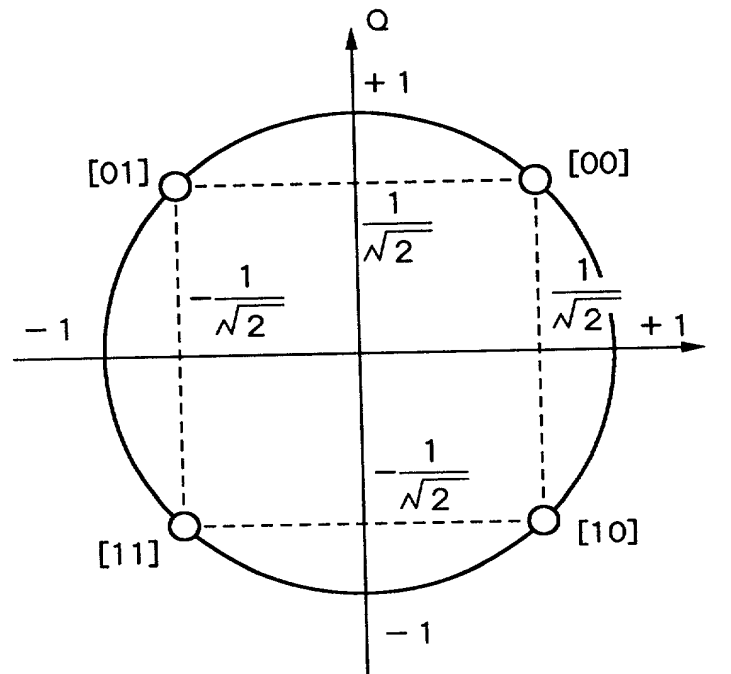


FIG.6A

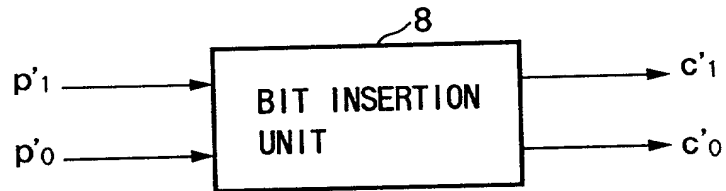


FIG.6B

DEPUNCTURING TABLE

$p'_1$	1	1	0
$p'_0$	1	0	1

FIG.7A

INPUT

$p'_1$	$X_1$	$Y_3$	$X_4$	$Y_6$
$p'_0$	$Y_1$	$X_2$	$Y_4$	$X_5$

FIG.7B

OUTPUT

$c'_1$	$X_1$	$X_2$	0	$X_4$	$X_5$	0
$c'_0$	$Y_1$	0	$Y_3$	$Y_4$	0	$Y_6$

FIG.8

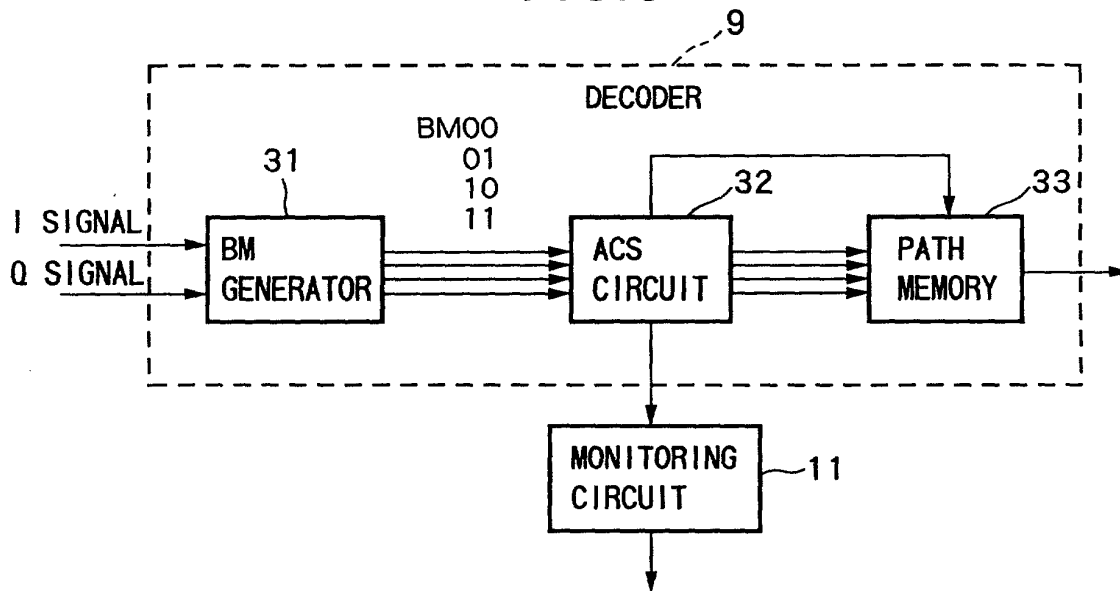


FIG.9

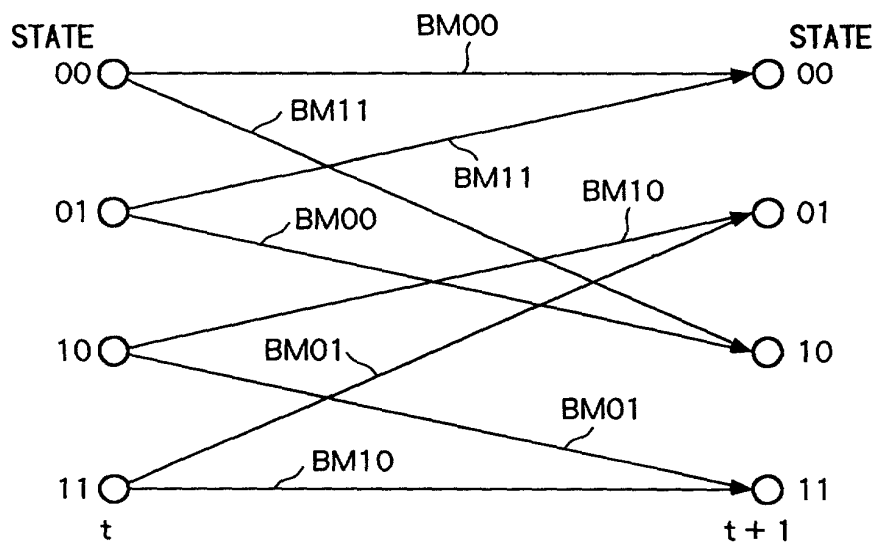


FIG.10

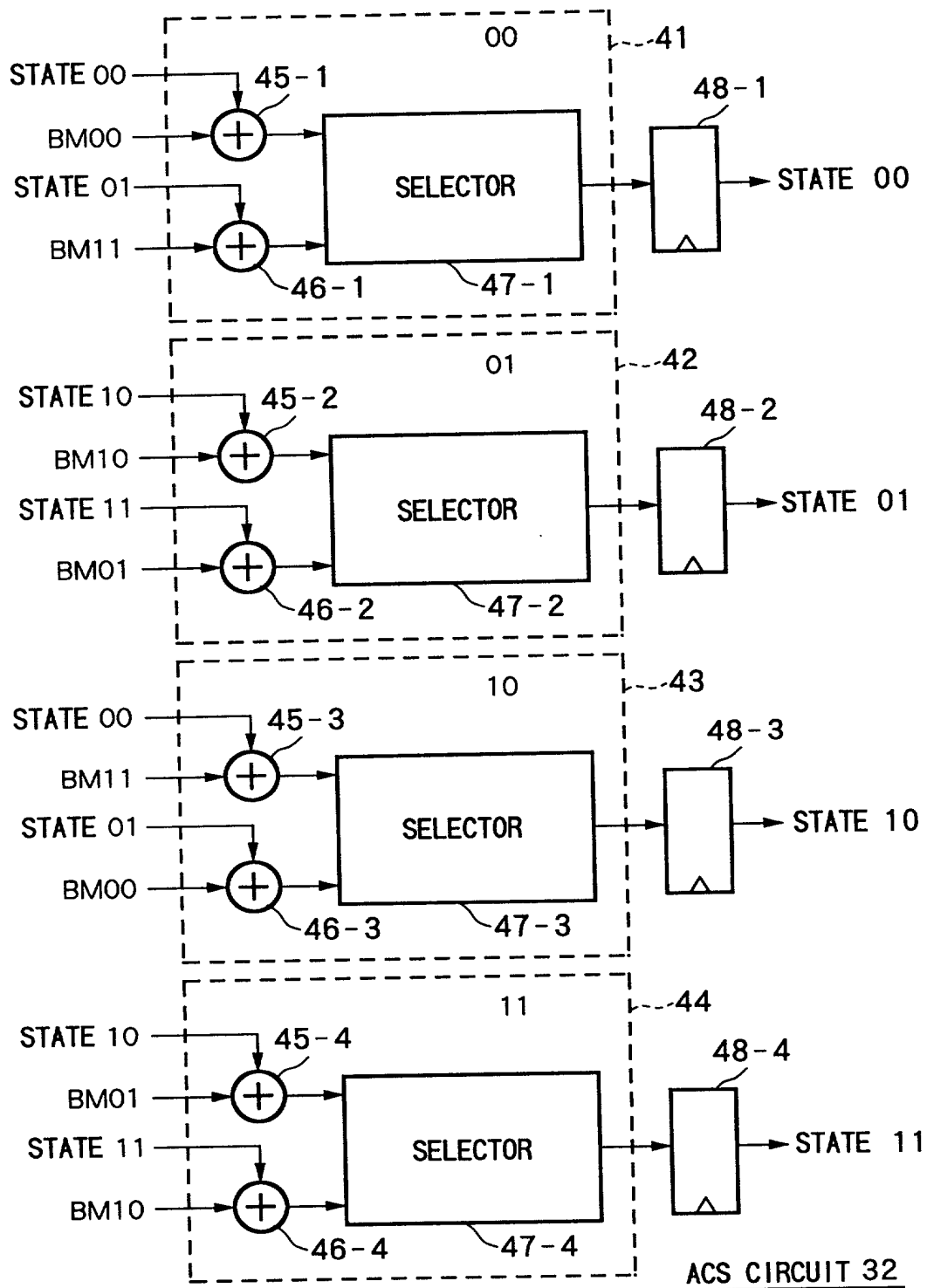




FIG.11

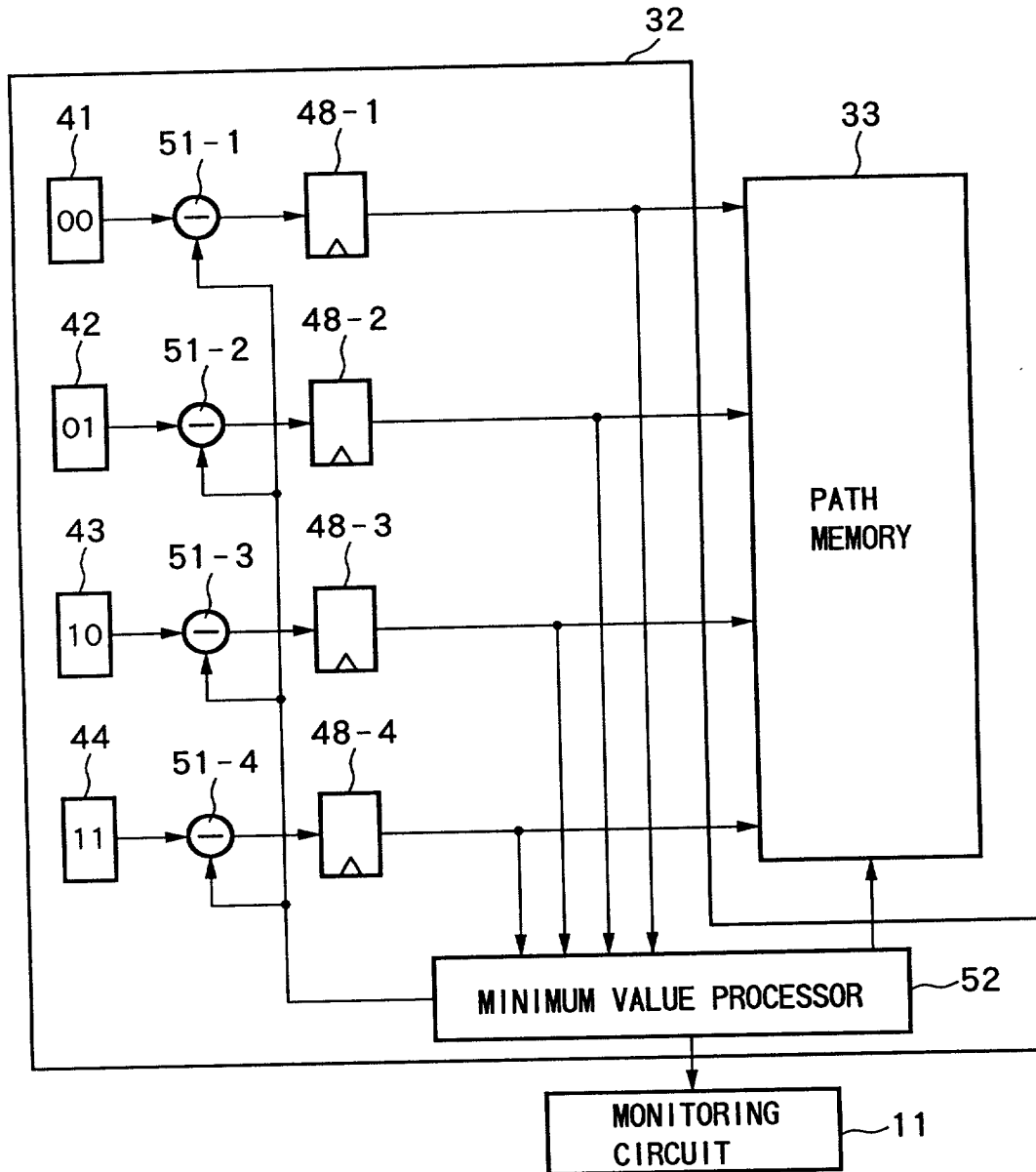


FIG.12

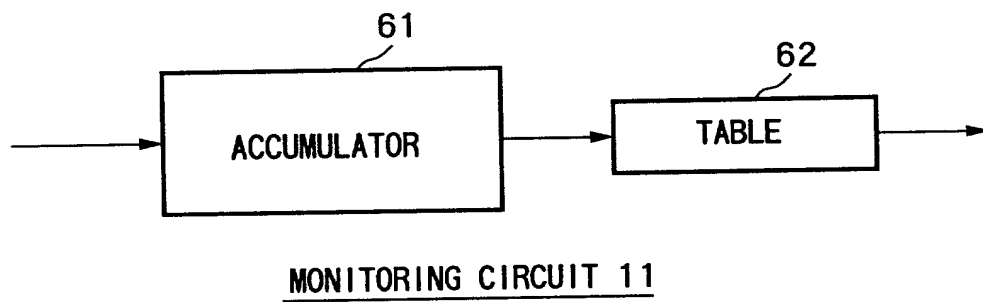
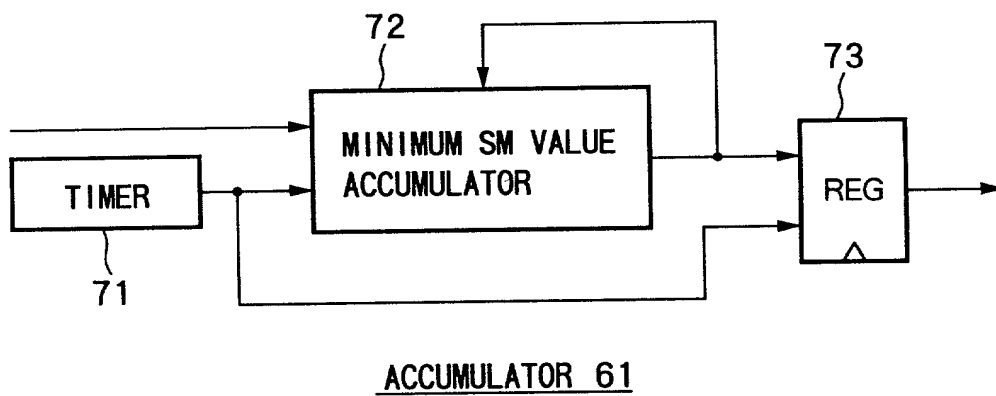


FIG.13



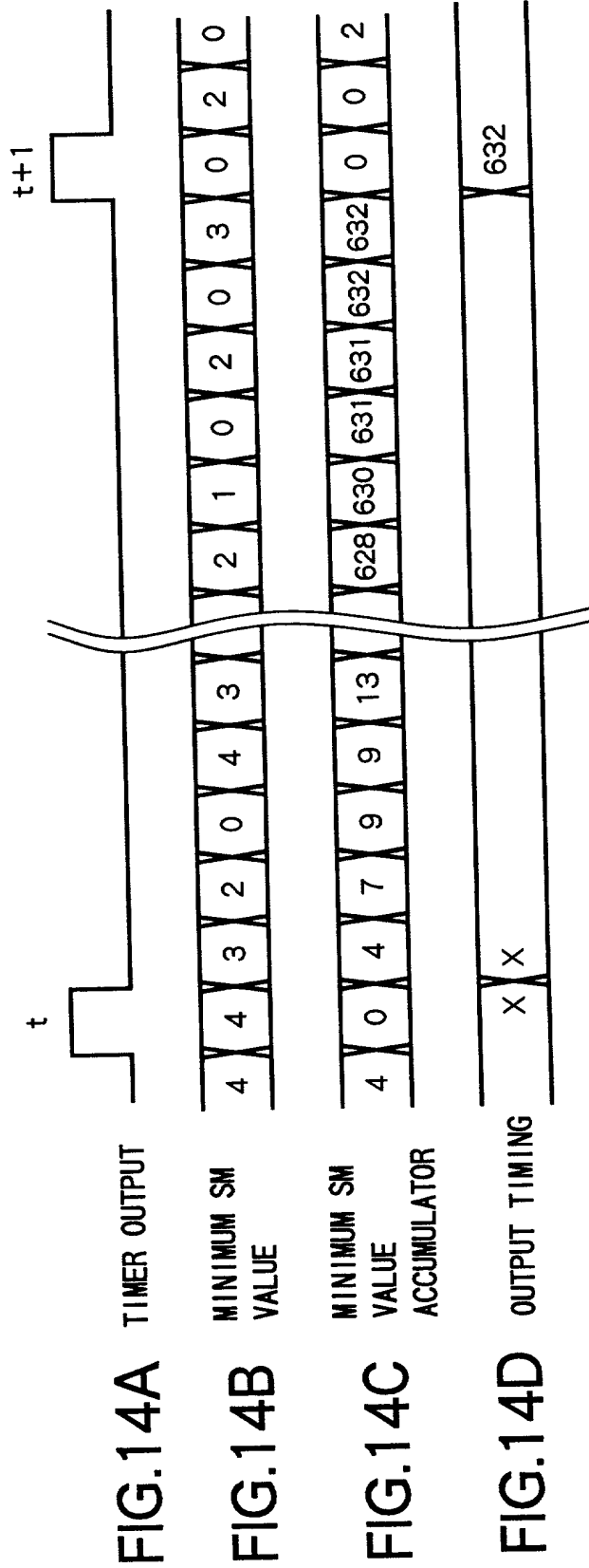


FIG.15A

QPSK $R = 1/2$	
ROM	
COUNTER VALUE	C/N
EQUAL OR MORE 22720	3.00
EQUAL OR MORE 22080 LESS THAN 22720	2.50
EQUAL OR MORE 21440 LESS THAN 22080	2.00
LESS THAN 21440	1.50

FIG.15B

QPSK $R = 3/4$	
ROM	
COUNTER VALUE	C/N
EQUAL OR MORE 36160	2.20
EQUAL OR MORE 35520 LESS THAN 36160	1.50
EQUAL OR MORE 34880 LESS THAN 35520	1.00
LESS THAN 34880	0.85

FIG. 16

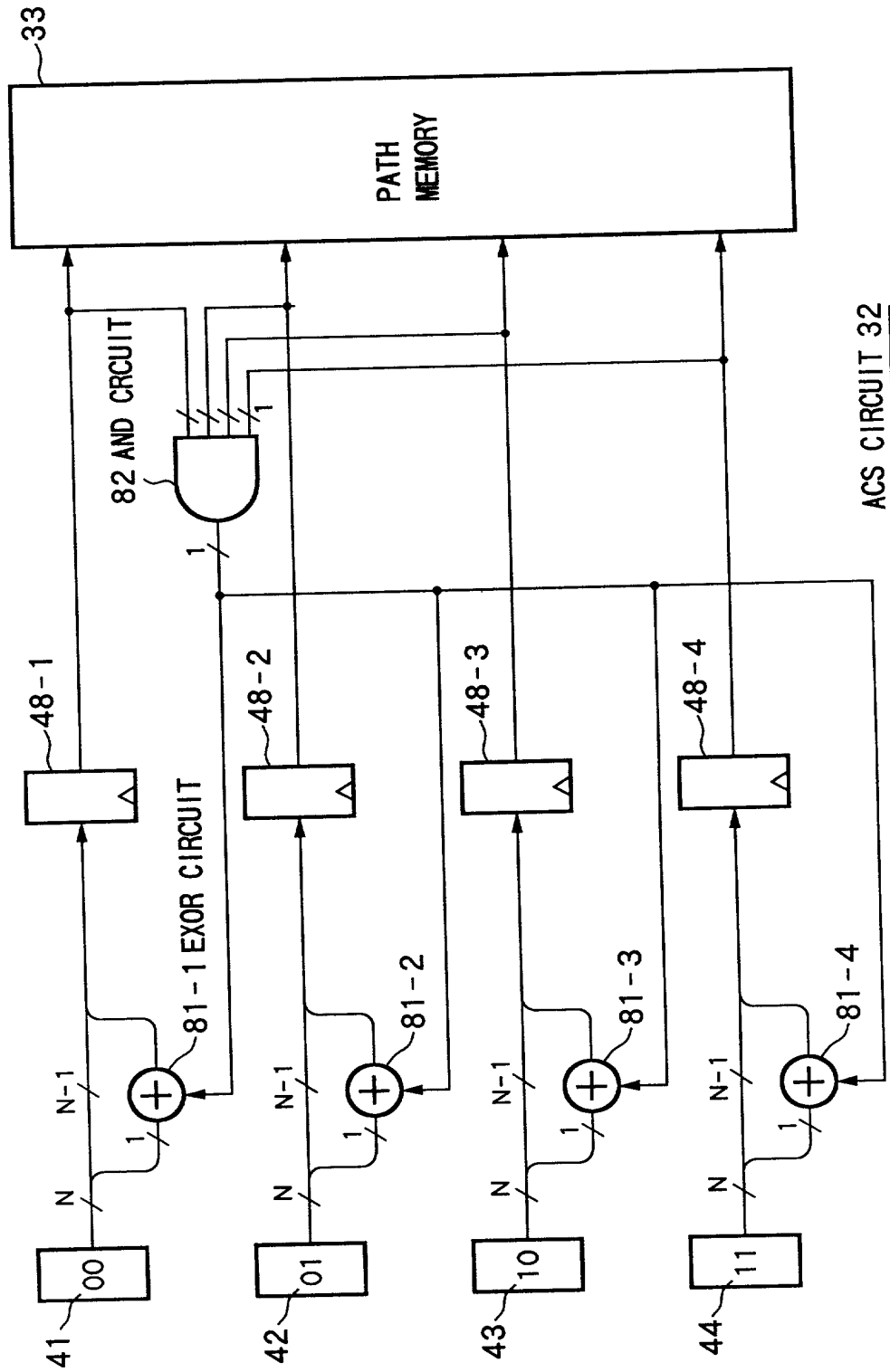


FIG.17

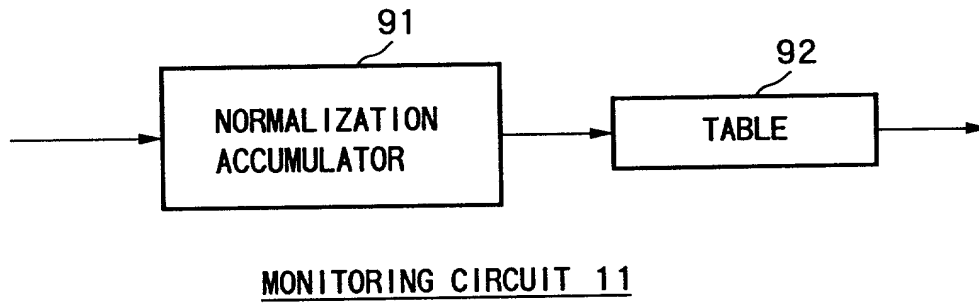
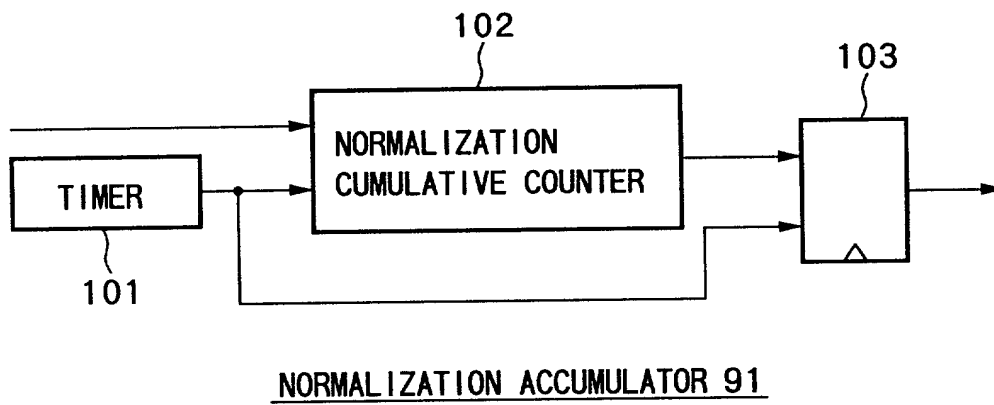


FIG.18



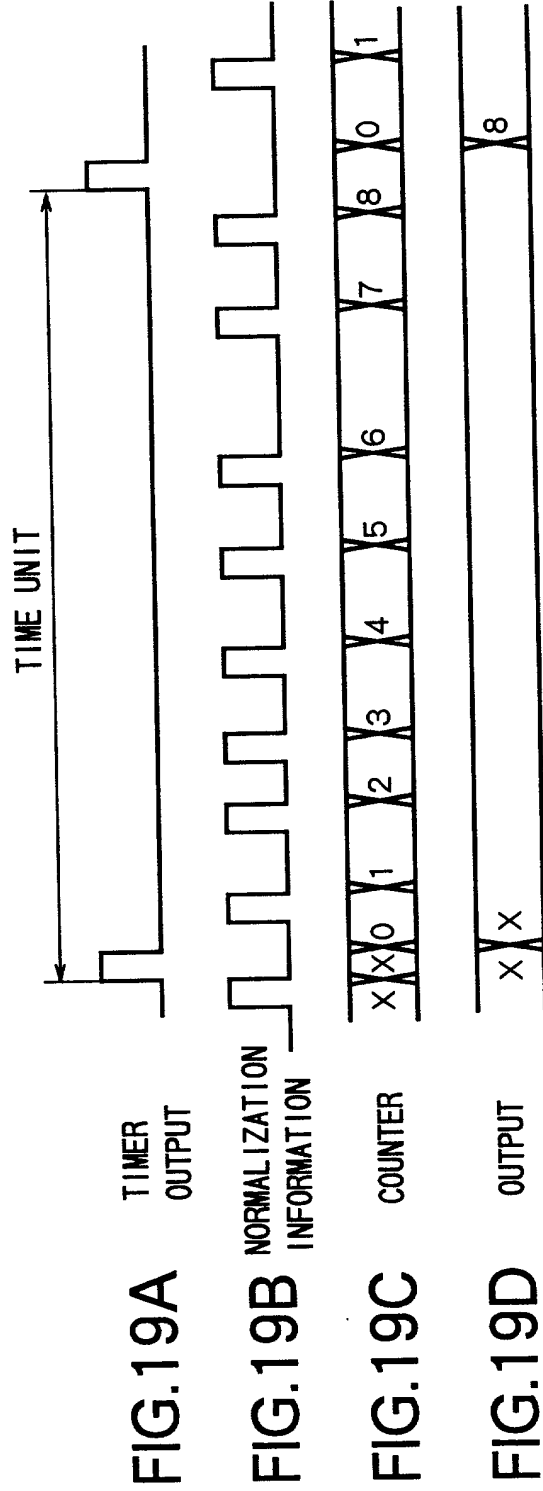


FIG.20A

QPSK $R = 1/2$	
COUNTER VALUE	BER
355 OR MORE	$0.50 \times 10^{-3}$
345 TO 354	$1.90 \times 10^{-3}$
335 TO 344	$0.80 \times 10^{-2}$
334 OR LESS	$0.20 \times 10^{-1}$

FIG.20B

QPSK $R = 3/4$	
COUNTER VALUE	BER
565 OR MORE	$4.80 \times 10^{-3}$
555 TO 564	$3.20 \times 10^{-2}$
545 TO 554	$1.00 \times 10^{-1}$
544 OR LESS	$1.90 \times 10^{-1}$



FIG.21A

QPSK $R = 1/2$	
COUNTER VALUE	C/N
355 OR MORE	3.00
345 TO 354	2.50
335 TO 344	2.00
334 OR LESS	1.50

FIG.21B

QPSK $R = 3/4$	
COUNTER VALUE	C/N
565 OR MORE	2.20
555 TO 564	1.50
545 TO 554	1.00
544 OR LESS	0.85

FIG.22

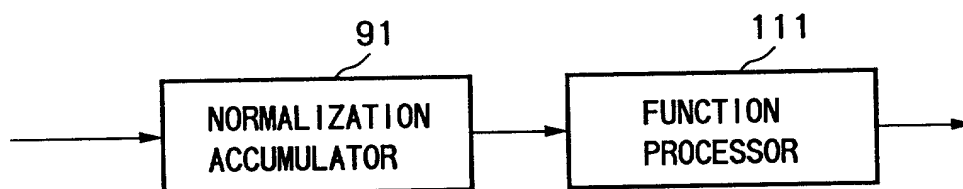
MONITORING CIRCUIT 11

FIG.23

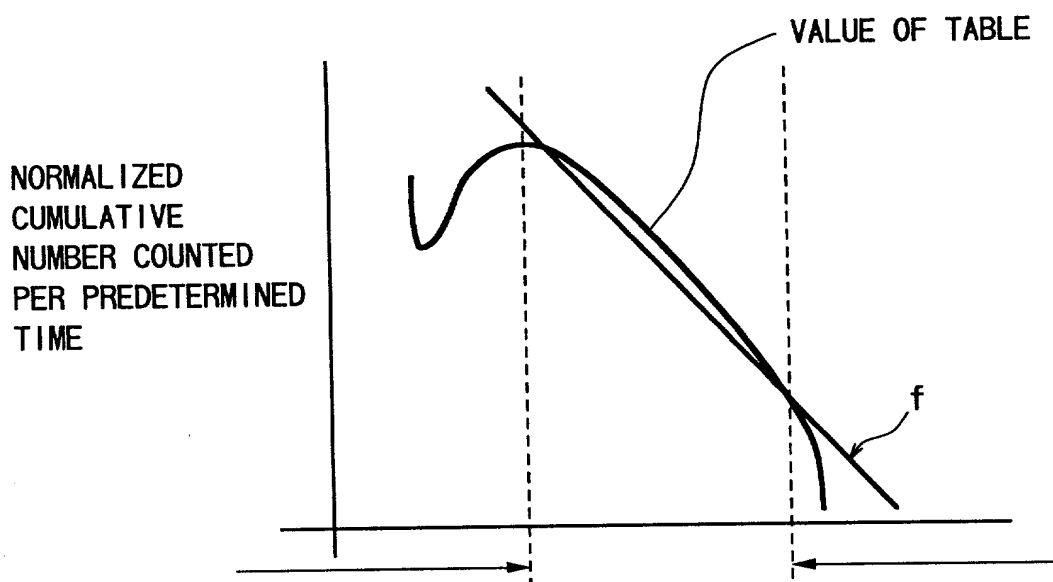


FIG.24

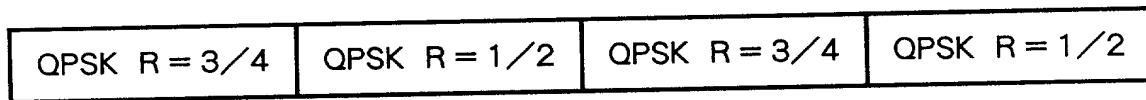


FIG.25

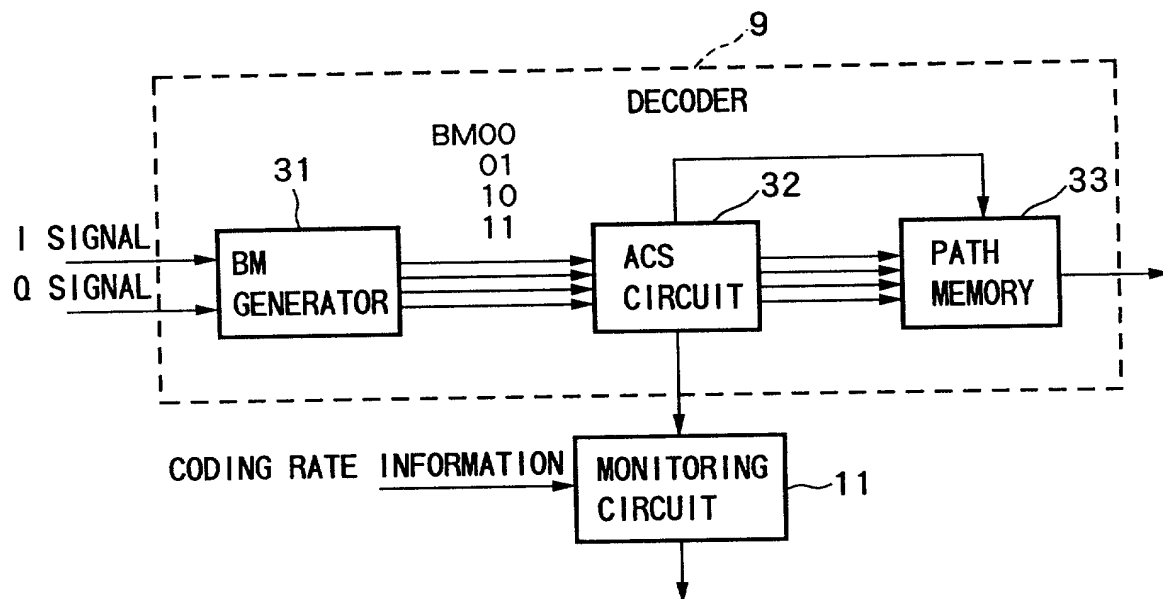


FIG.26

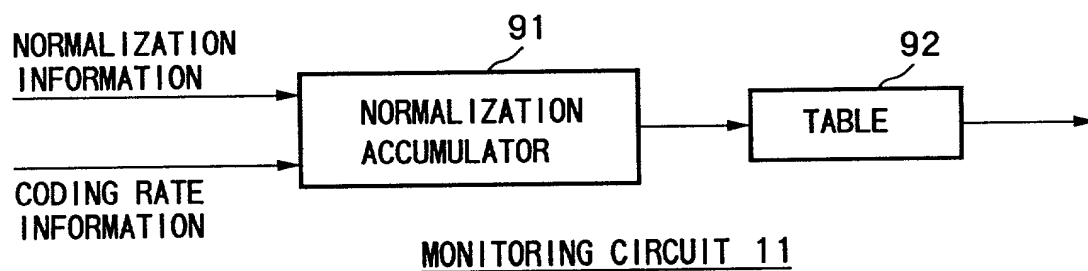
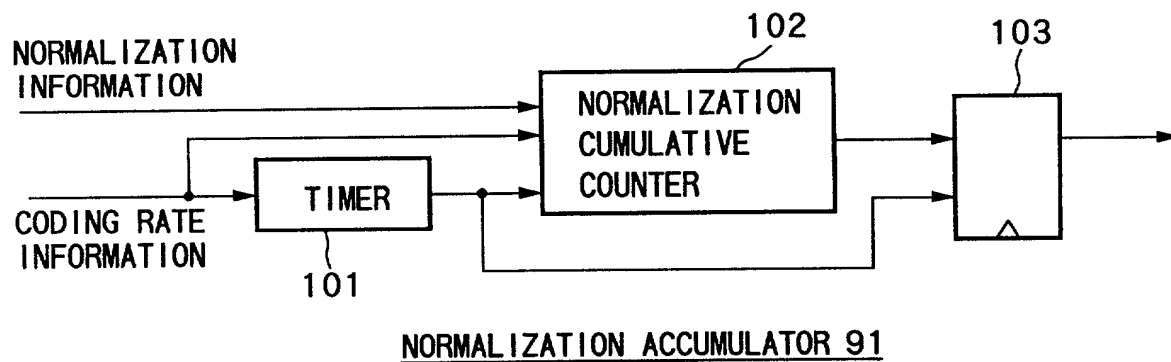


FIG.27



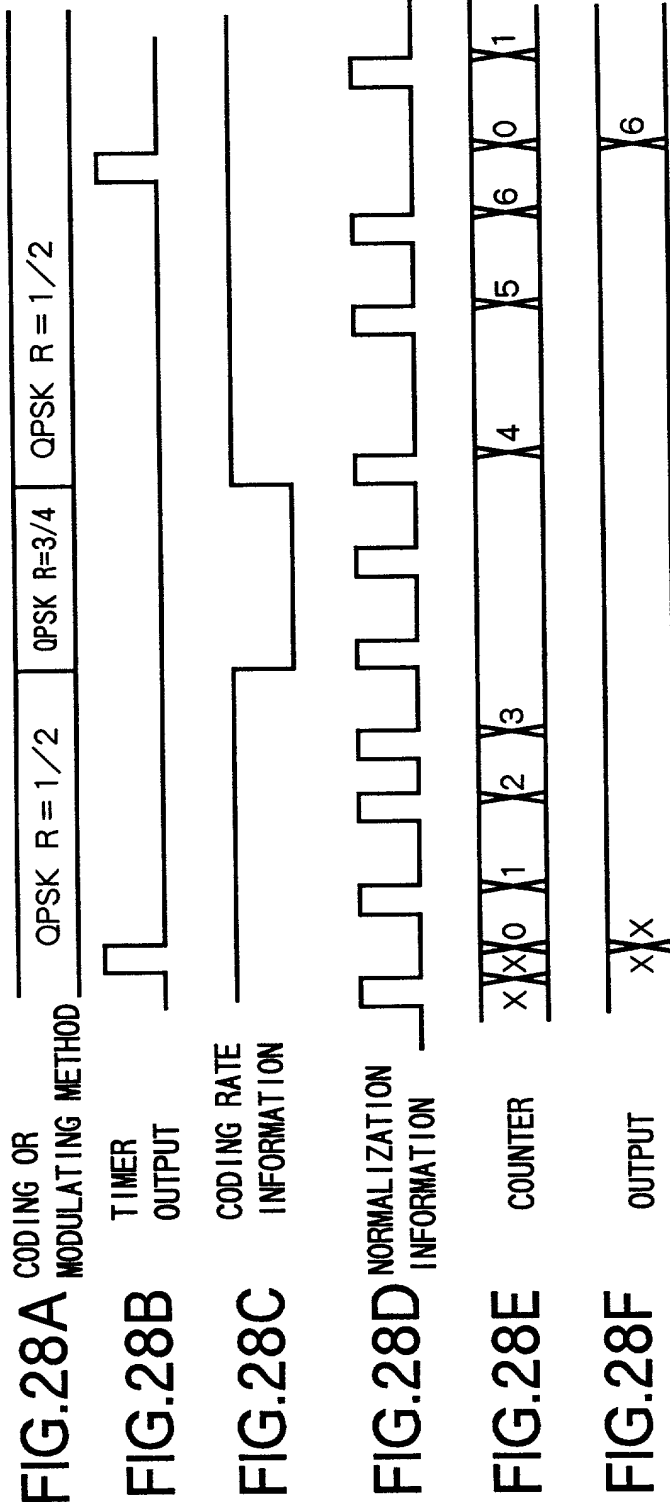
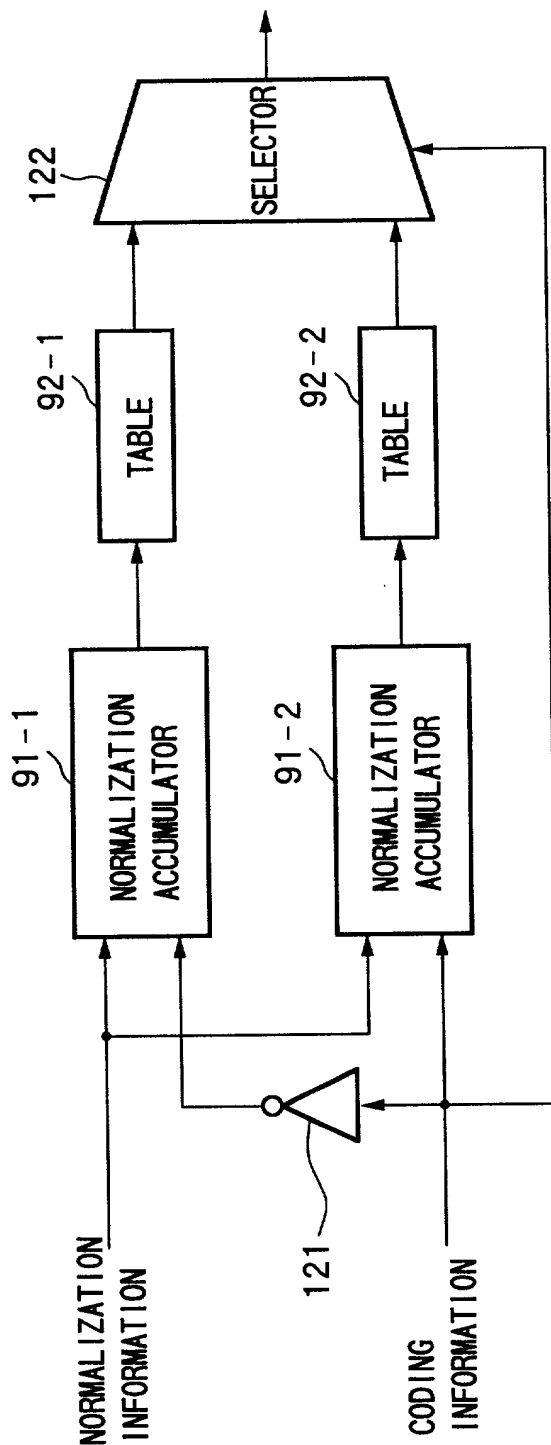
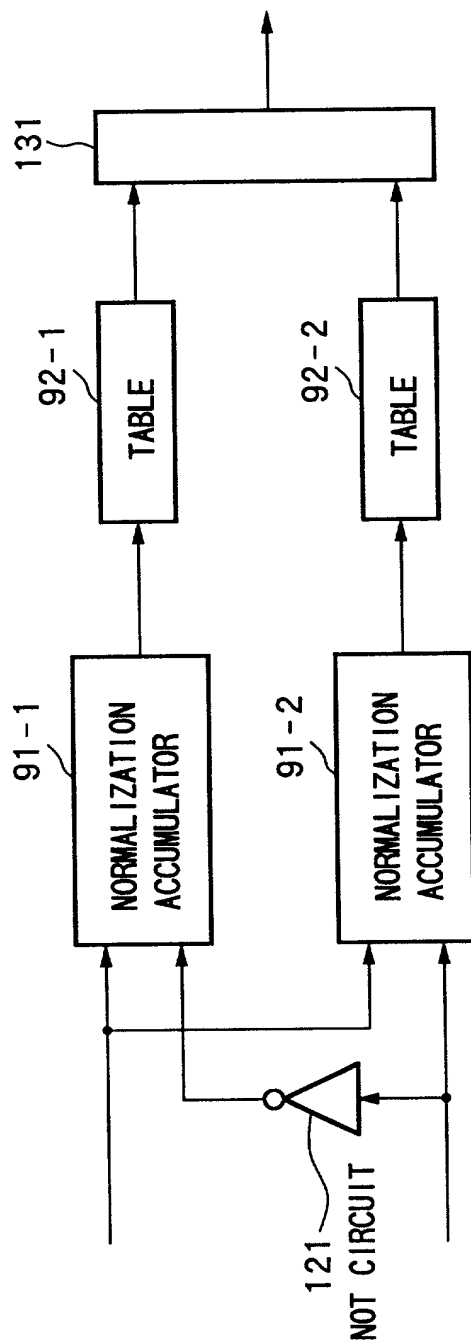


FIG.29



MONITORING CIRCUIT 11

FIG.30



MONITORING CIRCUIT 11

FIG.31

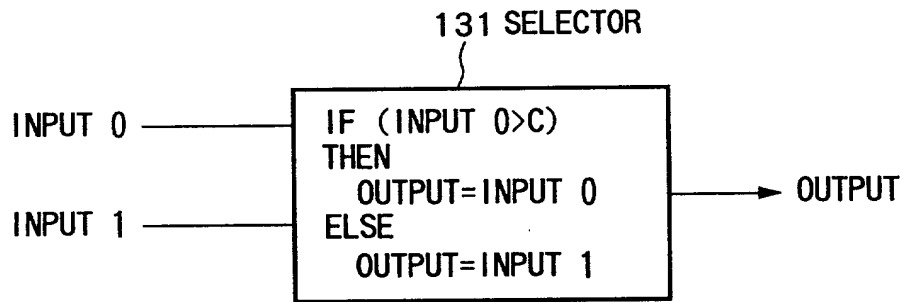


FIG.32

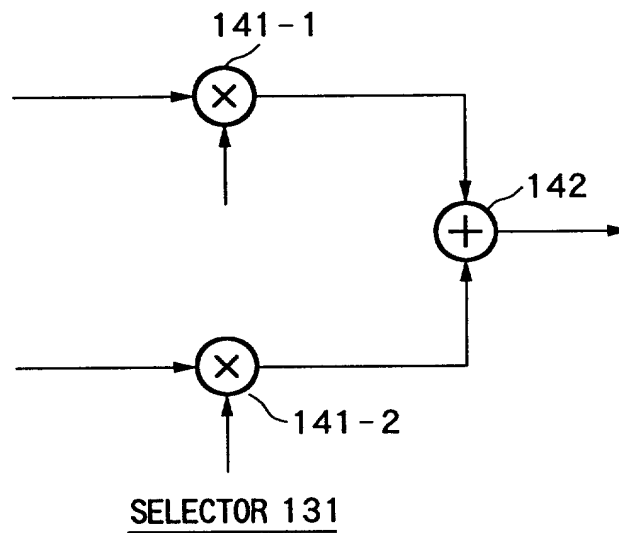




FIG. 33

ESTIMATED VALUE OF C/N IN QPSK TRANSMISSION AT R=1/2	WEIGHTING(QPSK R=1/2)	WEIGHTING(QPSK R=3/4)
FROM 2.0[dB] TO 3.0[dB]	1.0	0.0
FROM 1.5[dB] TO 2.0[dB]	0.5	0.5
1.5[dB] OR LESS	0.0	1.0

TABLE

FIG.34

CODING RATE OF QPSK R=3/4	WEIGHTING(QPSK R=1/2)	WEIGHTING(QPSK R=3/4)
EQUAL OR MORE 565	0.0	1.0
EQUAL OR MORE 565 LESS THAN 565	0.5	0.5
LESS THAN 555	1.0	0.0

TABLE

FIG.35

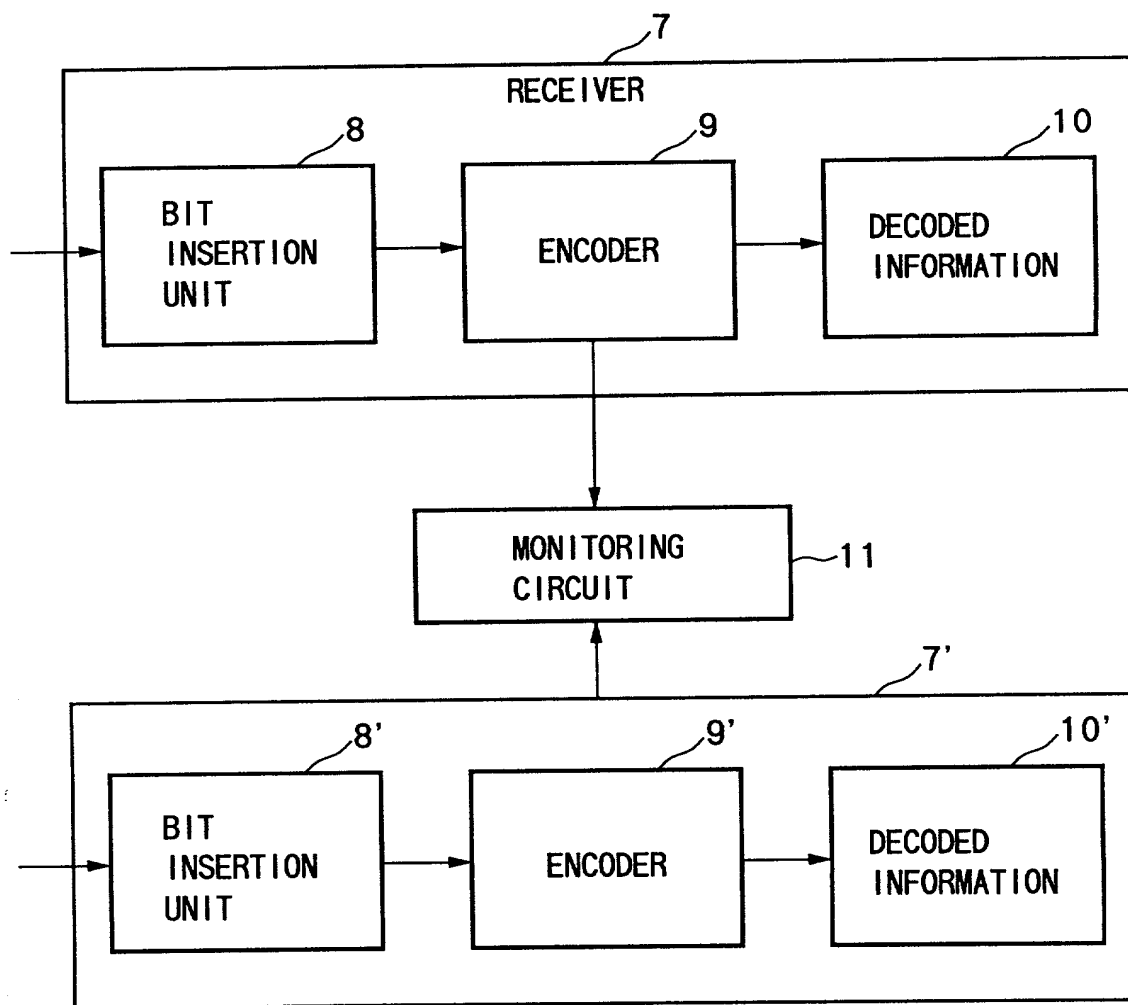


FIG.36

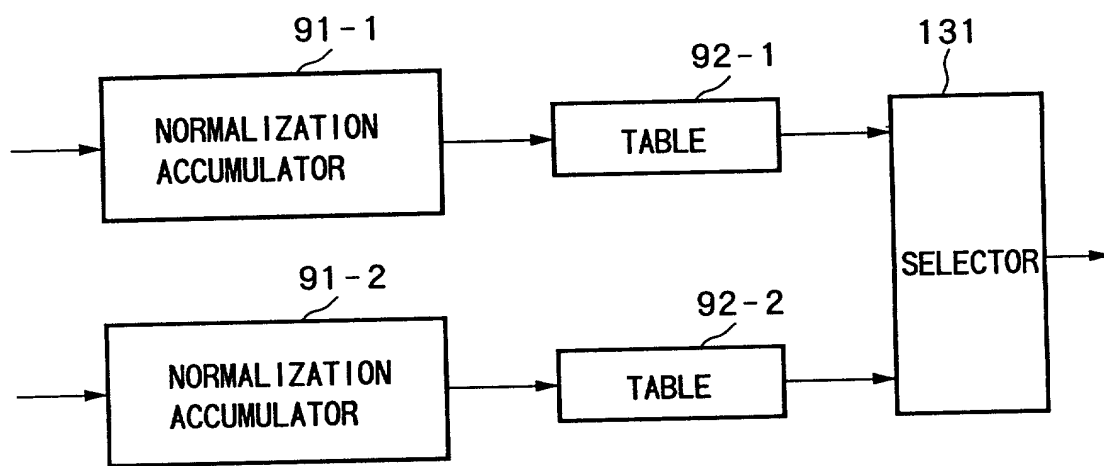
MONITORING CIRCUIT 11

FIG.37

ESTIMATED VALUE OF C/N IN QPSK TRANSMISSION AT R=3/4	WEIGHTING(QPSK R=1/2)	WEIGHTING(QPSK R=3/4)
2.20[dB] OR MORE	1.0	0.0
FROM 1.5[dB] TO 2.20[dB]	0.5	0.5
FROM 0.8[dB] TO 1.5[dB]	0.0	1.0

TABLE

FIG.38

1

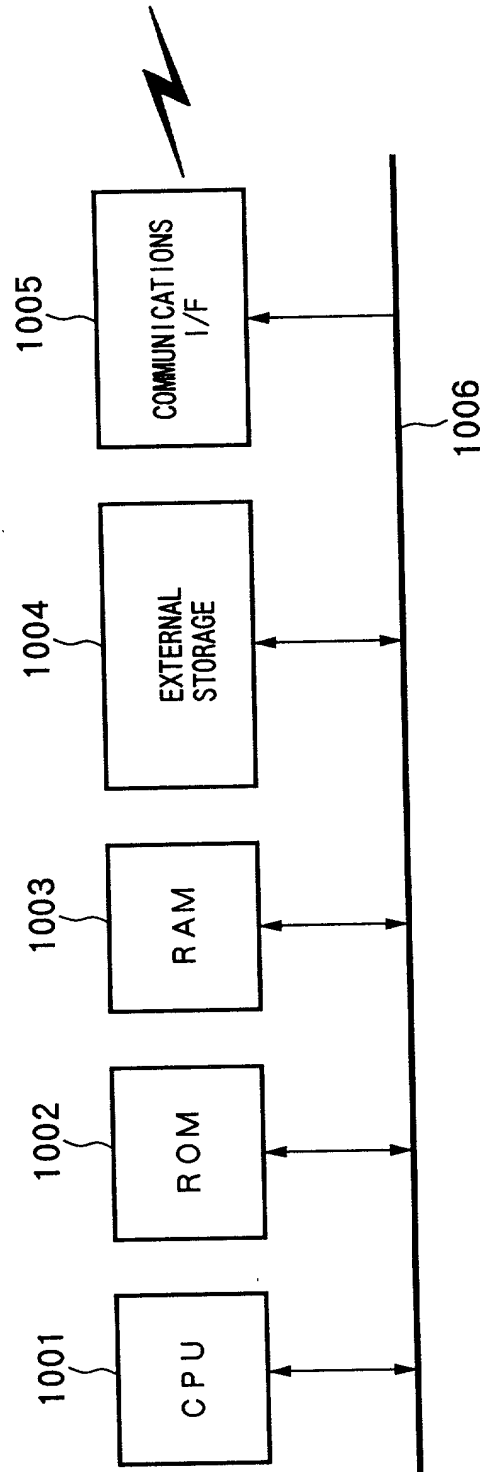
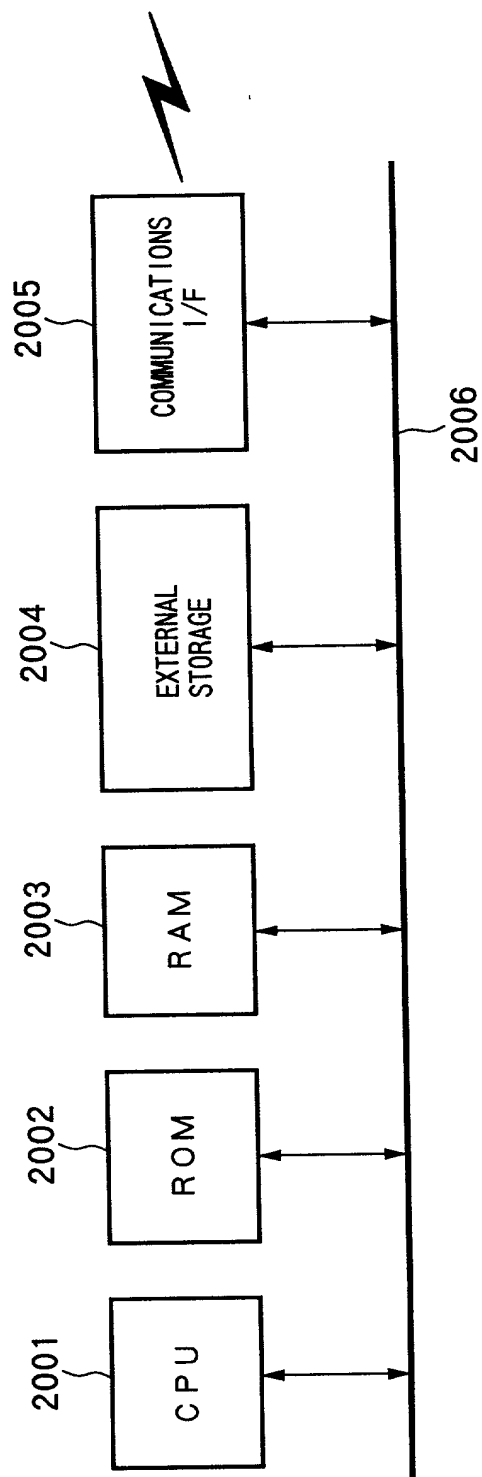


FIG.39

7



## 日本語宣言書

委任状：私は本出願を審査する手続を行い、且つ米国特許商標庁との全ての業務を遂行するために、記名された発明者として、下記の弁理士及び/または弁理士を任命する。(氏名及び整理番号を記載すること)

(2)

書類送付先

直通電話連絡先：(氏名及び電話番号)

**POWER OF ATTORNEY:** As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

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To the attention of: WILLIAM S. FROMMER

1-00

Full name of sole or first inventor

Atsushi INOMATA

inventor's signature

Date

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Tamotsu IKEDA

Second Inventor's signature

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(第三以下の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for third and subsequent joint inventors)



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## Declaration and Power of Attorney for Patent Application

### 特許出願宣言書及び委任状

#### Japanese Language Declaration

#### 日本語宣言書

私は、以下に記名された発明者として、ここに下記の通り宣言する：

As a below named inventor, I hereby declare that:

私の住所、郵便の宛先そして国籍は、私の氏名の後に記載された通りである。

My residence, post office address and citizenship are as stated next to my name:

下記の名称の発明について、特許請求範囲に記載され、且つ特許が与えられている発明主題に関して、私は、最初、最先且つ唯一の発明者である（唯一の氏名が記載されている場合）か、或いは最初、最先且つ共同発明者である（複数の氏名が記載されている場合）と信じている。

I believe I am the original, first and sole inventor if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

ERROR RATE ESTIMATING DEVICE, RECEIVER USING  
ERROR RATE ESTIMATING DEVICE, ERROR RATE  
ESTIMATING METHOD, RECEIVING METHOD USING  
ERROR RATE ESTIMATING METHOD, AND  
INFORMATION RECORDING MEDIUM

上記発明の明細書はここに添付されているが、下記の欄がチェックされている場合は、この限りでない：

the specification of which is attached hereto unless the following box is checked:

☐ \_\_\_\_\_ の日に出願され、  
この出願の米国出願番号またはPCT国際出願番号は、  
\_\_\_\_\_ であり、且つ  
\_\_\_\_\_ の日に補正された出願（該当する場合）

☒ was filed on January 5, 2000  
as United States Application Number of  
PCT International Application Number PCT/JP00/00013  
\_\_\_\_\_ and was amended on  
\_\_\_\_\_ (if applicable).

私は、上記の補正書によって補正された、特許請求範囲を含む上記明細書を検討し、且つ内容を理解していることをここに表明する。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

私は、連邦規則法典第37編規則1.56に定義されている、特許性について重要な情報を開示する義務があることを認める。

Burden Hour Statement: This form is estimated to take 0.4 hours to complete. Time will vary depending upon the need of the individual case. Any comments on the amount of time you are required to complete this form should be sent to Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner of Patents and Trademarks, Washington, DC 20231.

## 日本語宣言書

私は、ここに、以下に記載した外国での特許出願または発明者証の出願、或いは米国以外の少なくとも一国を指定している米国法典第35編第365条(a)によるPCT国際出願について、同第119条(a)-(d)項又は第365条(b)項に基づいて優先権を主張するとともに、優先権を主張する本出願の出願日より前の出願日を有する外国での特許出願または発明者証の出願、或いはPCT国際出願については、いかなる出願も、下記の枠内をチェックすることにより示した。

## Prior Foreign Application(s)

## 外国での先行出願

11-001790  
(Number)  
(番号)

Japan  
(Country)  
(国名)

PCT/JP00/00013  
(Number)  
(番号)

PCT  
(Country)  
(国名)

(Number)  
(番号)

(Country)  
(国名)

(Number)  
(番号)

(Country)  
(国名)

(Number)  
(番号)

(Country)  
(国名)

(Number)  
(番号)

(Country)  
(国名)

私は、ここに、下記のいかなる米国仮特許出願についても、その米国法典第35編第119条(e)項の利益を主張する。

(Application No.)  
(出願番号)

(Filing Date)  
(出願日)

私は、ここに、下記のいかなる米国出願についても、その米国法典第35編第120条に基づく利益を主張し、又米国を指定するいかなるPCT国際出願についても、その同第365条(c)に基づく利益を主張する。また、本出願の各特許請求の範囲の主題が、米国法典第35編第112条第1段に規定された態様で、先行する米国出願又はPCT国際出願に開示されていない場合においては、その先行出願の出願日と本国内出願日またはPCT国際出願日との間の期間中に入手された情報で、連邦規則法典第37編規則1.56に定義された特許性に関わる重要な情報について開示義務があることを承認する。

(Application No.)  
(出願番号)

(Filing Date)  
(出願日)

私は、ここに表明された私自身の知識に係わる陳述が真実であり、且つ情報と信ずることに基づく陳述が、真実であると信じられることを宣言し、さらに、故意に虚偽の陳述などを行った場合は、米国法典第18編第1001条に基づき、罰金または拘禁、若しくはその両方により処罰され、またそのような故意による虚偽の陳述は、本出願またはそれに対して発行されるいかなる特許も、その有効性に問題が生ずることを理解した上で陳述が行われたことを、ここに宣言する。

I hereby claim foreign priority under Title 35, United States Code, Section 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT international application having a filing date before that of the application for which priority is claimed.

## Priority Not Claimed

## 優先権主張なし

7 January 1999  
(Day/Month/Year Filed)

☐

5 January 2000  
(Day/Month/Year Filed)

☐

(Day/Month/Year Filed)

☐

(Day/Month/Year Filed)

☐

(Day/Month/Year Filed)

☐

(Day/Month/Year Filed)

☐

I hereby claim the benefit under Title 35, United States Code, Section 119(c) of any United States provisional application(s) listed below.

(Application No.)  
(出願番号)

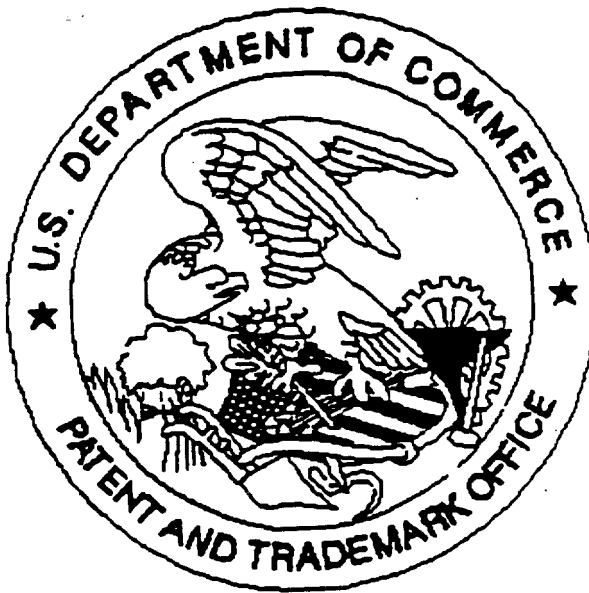
(Filing Date)  
(出願日)

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(Status: Patented, Pending, Abandoned)  
(現況: 特許許可、係属中、放棄)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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